Ref. Ares(2024)3737249 - 24/05/2024

SUPER-i

D2.2 Social housing EE investment projects initial database

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

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 101028220.

Technical references

Project Acronym	SUPER-i
Project Title	Extended Public-Private Partnership for Investment in Smart Energy Efficiency Projects in a Social Housing context
Project Duration	September 2021 – August 2024 (36 months)

Deliverable No.	D2.2
Dissemination level*	PU
Work Package	WP 2 - SUPER-i portal
Task	T2.1 - Mapping SUPER-i portal requirements and data
Lead beneficiary	13 (ELE)
Contributing beneficiary/ies	2 (UoY), 6 (CIRCE), 1 (CIVI)
Due date of deliverable	31 August 2022
Actual submission date	24 August 2022

* PU = Public

PP = Restricted to other programme participants (including the Commission Services)

RE = Restricted to a group specified by the consortium (including the Commission Services)

CO = Confidential, only for members of the consortium (including the Commission Services)

v	Date	Beneficiaries	Track changes
1.0	31/08/2022	ELE, CIRCE, UoY	First version
2.0	11/03/2024	ELE, CIRCE, UoY	Conclusions finalised
3.0	22/05/2024	ELE, CIRCE, UoY	Conclusions extended, automatic ToC updated
4.0	24/05/2024	UoY	Revision of the document

Table of contents

● Executive summary

This deliverable describes the process through which the SUPER-i project consortium collected the data allowing us to assess:

- the potential size of the energy efficiency improvements required for Europe's social housing stock in line with the EU carbon targets
- the available support by member state
- the impact of specific energy efficiency interventions for the sector, including specific modelling of the pipeline schemes, and the energy impact and cost savings associated with their proposed improvements

During this analysis, we have drawn both on primary (consultation with SUPER-i project pipelines) and secondary (literature review) sources.

In this document:

1. **Section 1** presents an overall view of the social housing investment projects identification, and reviews the situation in the states where the 3 pipelines are located - Denmark, Italy and Slovenia . We find that there are a wide range of support mechanisms using a variety of business models across Europe through which energy efficiency retrofit is incentivised, with national, local and EU-wide schemes. We find further that the state of housing, housing policy drivers and environmental ambitions for the built environment varying significantly across Europe:
    - In Denmark, around a fifth of the population live in social housing, most of which is built to a relatively high standard. Historically, the support available for energy efficiency retrofit and refurbishment has been primarily funded through residents paying into private funds, though the government has recently allocated significant resources to rapidly increase the rate of retrofit.
    - In Italy, less than 5% of the population live in social housing, though demand is expected to increase in the coming years, and a large share of the population experience fuel poverty by European standards. As a result, Italy has or will soon deploy a series of national schemes, and call on EU support to improve housing across the country in the coming years.
    - In Slovenia, a shortage of accommodation and ambitious green targets are the main factors shaping the housing agenda, with a range of grants and soft loans available for energy efficiency retrofit.
2. **Section 2** explains the model variable identification and data collection; in the first part we lay out the project pipeline information collected through the project data template - developed iteratively in concert with the project partner pipelines. In the second, we present the relevant national context we will use to carry out cost-benefit analysis based on the returns associated with the pipeline
3. **Section 3** presents the results of our work to assess the achievable economic potential of energy efficiency investment opportunities in social housing, and identify an initial set of

variables – considering both energy-related and non-energy related factors - to allow us to assess this for schemes across Europe, covering:

- number of buildings
- building stock evolution (increase/decrease)
- number of residents
- living area
- construction year
- Energy Performance Certificate (by age range)
- construction types (size)
- current energy intensity
- potential energy savings
- percentage of already EE refurbished buildings
- volume of investments into EE in Social Housing
- investment/savings (€/MWh) or inverse
- occupancy rate
- vacancy rate
- “emptiness” rate of non-rented for any reason.

We also lay out the research that will allow us to carry out life cycle analyses (LCAs) using the results of the previous sections.

1. Social housing investment projects identification

Given the existing limitations around private investments in social housing, governments have proposed various types of support to reduce their cost and make them more financially attractive. Among these types of support are:

- financial and/or fiscal mechanisms such as guarantees,
- subsidies for the financing of developers,
- elimination of risks facilitating access to building land, among others.

Intermediate parties, known as aggregators/financial intermediaries, have also been established to reduce the scale of these mechanisms and be able to channel investments at the local level. Despite the efforts made, some limitations to work within the framework of private investment remain, requiring the support of the public sector in the vast majority of cases, although the possibility of diversifying the financing of social housing has been raised.

In this environment, Public-Private Partnerships (PPPs) are useful platforms to overcome the problem of financing, since they take advantage of the benefits of both systems: they use the services provided to the public sector, while reducing budget restrictions established to the public sector through the private sector.

Against this background, the growing involvement of the European Investment Bank (EIB) has been welcomed; in response to the EU's political objectives around the fight against poverty and climate change, affordable and social housing has become a priority area for the EIB, which is taking a leading role in investments both at local and local and national level (with or without the use of the European Fund for Strategic Investments as guarantee). The EIB also manages the investment fund (InvestEU). Among its 4 windows of action, the one for Social Investment and Skills will generate new options and opportunities for providers of social and affordable housing in the period between 2021 and 2027.

Since EIB usually gives loans of more than 100 million euros, financing is distributed to the housing sector through different intermediate bodies ranging from governments and local administrations (municipalities and regions), public aggregators at the national level (such as the Housing Agency in Ireland), sector-specific intermediaries (such as the Housing Finance Corporation in the UK) or National Promotional Banks (including, for example, Caisse des Depots in France or Bank Gospodarstwa Krajowego in Poland). It is informative here to highlight the better performing models, especially in Denmark and France, in which the management of EIB loans have been granted to housing organisations and/or groups of housing companies, which have closer knowledge of the operation of this type of housing.

For its part, the Development Bank of the Council of Europe has also granted loans to the sector, financing the acquisition of social housing for the vulnerable population. Investment in this topic amounts to 30% of the proportion of total loans in line with sustainable and inclusive growth. In this way, more than 700 million euros of project finance has been provided, which has benefited more than 30,000 families.

1.1.Denmark

Statistics on social housing in Denmark are included in the following table:

	# Of units	% Age of Total
Social housing	558,761	21%
Private rental	711,155	26%
Owner-occupier	1,326,304	49%
Other	114,044	4%

Table 1. Statistics on Social Housing in Denmark. Source: Statistics Denmark

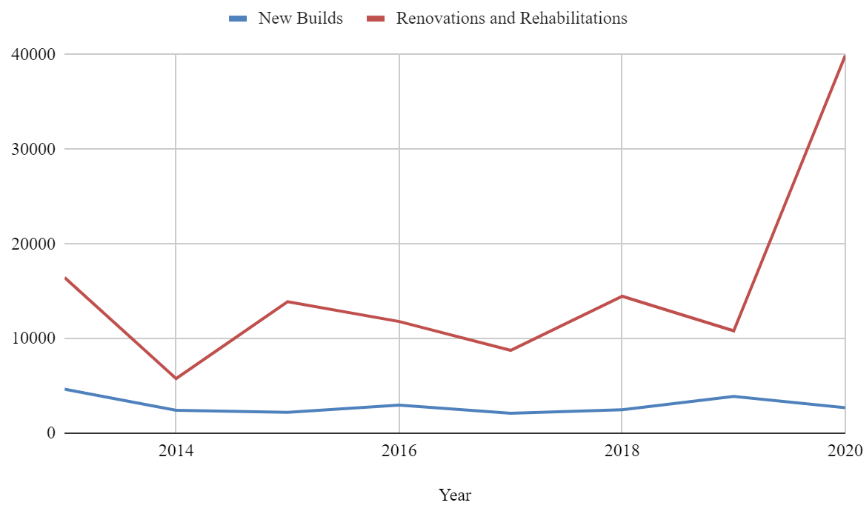

Figure 1. Supply and renovation of social rental housing. Source: Statistics Denmark; BL

In Denmark, the share of non-profit housing differs between local authorities, with some showing more than 50% of the housing stock while others show less than 5%. In total, it represents 600,000 dwellings and about 1 million people in Denmark, that is, one in six of the population. In recent years local government has been very proactive with energy renovation of social housing units, so much so that during 2020 the number of renovations of this type increased by around 4 times compared to the previous year. This partly reflects the 'Green Housing' agreement reached by housing providers and the Danish government to provide resources additional for such actions; as well as the work of the Boligselskabernes Landsforening (BL), the Danish federation for social housing, which developed an expert advisory council made up of representatives from all levels of the planning and construction process to streamline the process; and the government's strategy that granted temporary housing to tenants while works were carried out on their homes.

The aforementioned Green Housing initiative will see 4 billion euros invested between now and 2026, renovating tens of thousands of social housing units. In addition to the Green Housing agreement, a green guarantee scheme is being launched under the Danish National Building Fund, which will increase the incentive for more energy renovations and contribute to the spread of energy service company 'ESCO' solutions. Finally, a development pot has been allocated for sustainable investments in recyclable building materials, digital tracking and management of energy consumption, and improvement of the ventilation.

Financing of energy efficiency improvements in buildings has historically been primarily privately funded, with building owners having easy access to capital to improve their buildings through the Danish mortgage system. The system is based on the match funding principle, that is a direct match between the loan which a homeowner asks for (via a mortgage institute) and bonds which the same mortgage institute issues to fund the respective loan. The non-profit social housing sector is similar to a public-private partnership (PPPs). The financial model for the construction of new buildings[1] is mainly based on mortgage loans - these cover 90% of the total. The state, local authorities (municipalities) and tenants (only a residual 2%) cover the remaining portion

Building improvements are primarily financed out of the National Construction Fund, a private fund founded in the 1960s that is financed by tenants. This Fund is based on the rent payments of tenants living in social housing over the years and is a self-financing (i.e. not public) system for social housing. The purpose is to co-finance major renovations, including building retrofits and energy upgrades, organised in local associations (school, municipality, NGO, etc.) and allows social and affordable housing operators to be self-financing, i.e. not using only public financing. Most social housing is owned by non-profit housing cooperatives, and most are members of the non-profit Federation of Housing Associations. Social housing committees (members appointed by tenants) or individual tenants can take the initiative for the renovation or refurbishment of specific social housing. Some safeguards exist around this process, for example where the rent increases more than 15% due to renovation/refurbishment a majority vote including all tenants is required, as well as the approval from municipal authority. Nevertheless, this model has contributed to increased rents in social housing, making it difficult for low-income households to afford the refurbished dwellings.

Private sector experience of investment for energy saving in social housing has been limited, though involvement is growing. ESCO arrangements have seen some developments, with some political measures related to the EU Directive on Energy Services, such as the Energy Action Plan being brought in. For example, in the public-private partnership "State of Green", the Danish Government created 14 climate positive partnerships. A consensus seems to me emerging around the ESCO model, which can align incentives efficiently; the ESCO supplier can provide loans for energy renovation and is repaid through the energy savings.

One relevant example is the improvement of the 'BedreBolig' scheme. In this scheme, homeowners have access to a comprehensive solution for the energy renovation of their homes on the basis of a one-stop shop concept. This concept allows the participation of the financial sector and municipalities as initiators for building owners. Another example is the energy savings based on subsidy schemes. In many cases, there is a long payback time for individual projects, creating a

[1] Excluding the running costs and potential renovations and refurbishments.

barrier to the necessary investment. With the development of the “building fund”, private households can apply for a subsidy when renovating their energy and converting, for example from an oil or gas boiler to heat pumps, and a combination of energy renovations and conversions. In municipal buildings, the investments in energy savings are not considered to be municipal capital expenditures if financed by a private ESCO partner. Therefore, there are now ongoing several initiatives for energy savings in public buildings taking into account new targets until 2030 and the EU Energy Efficiency Directive.
More recently, in 2020, 30 billion DKK were allocated from the National Building Fund to a renovation scheme of social and affordable housing until 2026. The objective is to support a balanced green transition of the social housing stock. 18.4 billion DKK (2.4 billion €) were used for the renovation of 72,000 units in 2020 and 2021, the remaining 11.6 billion DKK (1.5 billion €) have been allocated to further renovations until 2026. The renovations are expected to reduce energy consumption by 30% to 40% as well as improve indoor health and maintain affordable rents.
Under the financing model for large-scale renovation projects and social development plans, social organisations apply to the National Building Fund. Around two thirds of the rent from tenants is then allocated to the National Building Fund when the original mortgage loan is paid off. The National Building Fund acts in a solidary structure as a savings account for the entire social housing sector in Denmark.

Some support exists for fuel poor households, particularly for pensioners, those receiving other state benefits, and those in unexpected financial difficulties. The Danish Energy Agency has financed an advice scheme aimed at helping and advising homeowners who want to replace their oil-fired or natural gas boilers with another form of heating. Moreover, a knowledge centre was created to collect and disseminate knowledge about practical ways to reduce energy consumption in buildings. The knowledge centre helps the parties in the construction industry to improve their qualifications and gain new tools to implement energy saving measures in buildings.
The knowledge centre is aimed both at the construction industry and individuals seeking advice and guidance. Since 2016 there are direct requirements for over 50 product types, and the regulation imposes further requirements on a large number of products. The schemes cover household appliances and building components (e.g. windows) and products aimed at enterprises (e.g. various types of pump, electric motor, etc.).

1.2. Italy

Statistics on social housing in Italy are included in the following table:

	# Of units	% Age of Total
Social housing	954,161	3.8%
Private rental	3,468,141	14%
Owner-occupier	17,691,895	72%
Other	2,468,993	10%

Table 2. Statistics on Social Housing in Italy. Source: Istat, 2011 Population and Housing Census

The supply and renovation of social rental housing can be seen below:

Year	New Builds	Renovations	Rehabilitations
2013	N/A	N/A	
2014	4557	11423	4999
2015	N/A	N/A	
2016	1111	3437	1174

Table 3. Renovation of social rental housing in Italy. Source: Federcasa

Although Italy has one of the highest number of dwellings per inhabitant across Europe, the social housing sector is comparatively small, comprising less than 4% of the country's total housing stock. According to estimates by the research institute Nomisma, in the coming years 1 million households not in social housing will experience housing deprivation, and there will be an increase of up to 40% in the proportion of households with rent arrears in the private sector.

Additionally, there is increasing demand for affordable and social housing for certain population groups, such as students and young people, as well as new shared housing solutions for the elderly population (such as intergenerational housing).

As a result of these conditions, Italy will become the main beneficiary of the funds allocated by Next Generation EU. 2 billion euros have been allocated, which will be used for the improvement of the existing public housing stock, including energy rehabilitation (from class G to E) and anti-seismic measures. With these funds, Italy intends to renovate 20% of the public housing stock, finance urban renewal projects and increase the supply of affordable social housing and student housing.

In addition, in July 2020 the 'Superbonus 110%' was implemented. It is a financial measure that reduces the income tax on 110% of the expenses for works related to energy rehabilitation, anti-seismic renovation, the installation of photovoltaic panels and/or the installation of structures/chargers for electric cars. It targets all candidate investors; private households, condominiums, cooperatives, public providers and NGOs and associations. The Superbonus also allows them to transfer the tax credit to a third party when the owner cannot afford the initial investment. An extension of this measure is planned within the framework of the recovery plan. Further, the 'national programme to enhance housing quality' (approved at the end of 2019, prior to the COVID crisis) made available over €853 million for the period 2020-2030. Regions, municipalities and metropolitan areas can apply for funding under this programme.

As indicated in the ENEA report (Italian National Agency for New Technologies, Energy and Sustainable Economic Development) "Energy Efficiency trends and policies in Italy" social housing in Italy can benefit from the following further measures incentivising energy retrofitting work:

- Ecobonus: a tax deduction of 110% of the expenses incurred for energy efficiency and seismic risk reduction in Italy. This measure was applicable for expenses incurred from 1st July 2020 until 31st December 2021 and the 110% deduction could be recovered in 5 annual instalments.

- National Energy Efficiency Fund: this is an investment fund targeting to invest up to €175m in energy efficiency ("EE") projects and small/medium-scale renewable energy ("RE") projects, mostly solar PV.

Additionally, Public Private Partnerships have been already successfully trialled in Italy and there is scope for further application of these schemes and a possible combination with Green Public Procurement (GPP).

1.3. Slovenia

Statistics on social housing in Slovenia are included in the following table:

Category	# Units	% Age of total
Not for profit rental housing	39,800	6%
Private rental	12,800	2%
Owner-occupier	549,440	81%
Other	77,960	11%

Table 4. Statistics on Social Housing in Slovenia. Source: Republic of Slovenia Statistical Office

The Slovenian housing system is dominated by owner-occupiers. Along with this, centralism and large regional differences in housing prices limit internal migration and labour market mobility, and thus also the economic projections of low-income households far from economic centres.
There is a growing young population struggling for financial independence, and the ageing of the population requests public housing programs to ensure future needs.

Estimates from the Slovenian government indicate that the country is short of 10,000 public rental housing units and the Housing Fund of the Republic of Slovenia (HFRS) indicates that between 1,000 and 1,500 new public rental units will be needed annually, with only a small fraction of this being achieved annually. As such, the HFRS has assisted the Slovenian government in developing the country's National Recovery Plan - with a budget of more than 2 billion euros to be provided in subsidies and guarantees through the Next Generation EU funds, there is an effort to put affordable housing at the centre of the investment agenda.

In 2020, Slovenia adopted the National Energy and Climate Plan, its objectives are set to 2030, specifically achieving 35% of energy efficiency by 2030 (in comparison to a reference scenario based on 2007 data) and leading to reductions in the primary energy consumption. Previous analysis has highlighted the importance of a framework including directly related measures such as:

- energy performance contracting
- financial incentives for implementation of EE and renewable energy sources (RES) measures in residential buildings
- instruments for financing renovation in buildings with multiple owners
- distribution of incentives among owners and tenants in multi-apartment buildings

- establishment of a guarantee scheme
- financial incentives for the deep renovation of buildings in the public sector
- introducing an energy management system in the public sector
- public buildings energy renovation projects implementation unit.

The residential sector is subject to a twin target that will drive the retrofit of the building stock: to reduce final energy consumption by 20% and to reduce GHG emissions by at least 70% by 2030 (in comparison to 2005 levels). There are financial subsidies in the form of soft loans for the implementation of efficient/renewable heating technologies. The main stakeholders are the central government and financial institutions. The goal of these instruments is to drive the implementation of energy efficiency measures that decrease the energy consumption for space heating in residential buildings. This includes the replacement of old inefficient boilers, use of condensing and modular boilers, and the use of renewable energy sources for heating such as biomass boilers, thermal solar and heat pumps. These financial incentives started in 2008 and are due to end by 2030.

In order to achieve these National Energy and Climate Plan targets, grants are available to finance renovation in buildings with multiple owners, and regulations regarding governing decisions in multi-apartment buildings have been streamlined. Moreover, the plan also pushes the increase of the efficiency through distribution of incentives across owners and tenants in multi-apartment buildings. The incentives include guarantee schemes for risk-sharing, refinancing of investments (factoring, repurchase of green bonds), and capital injections for new Energy Service Companies (ESCOs).

The national Eco Fund (named Eko Sklad) which provides soft loans to the residential sector is co-financed by a range of funding sources (e.g. EC Phare Programme, EIB, IBRD, World Bank). External funding can be also used to accelerate the pace of building renovations.

In the Operational Programme for the Implementation of the EU Cohesion Policy in the period 2014-2020, Slovenia has adopted a decision that by the end of the programming period, in the year 2023, 1.8 million m^2 of floor space in the public sector will undergo energy renovation. To fulfil the target, yearly investment needs in the period 2016 - 2023 are at the level between €51 million and €53 million, totalling €415 million across the period. Energy efficiency investments in deep renovation of public buildings are financed from the European Structural and Investment Funds (ESIF) – Cohesion Fund, using financial instruments and EPC. The Operational Programme for the Implementation of the EU Cohesion Policy shows the role of public bodies' buildings and accelerates roll out of the EPC as a key mechanism by providing €147.5 million of Cohesion grants and €25 million of EU funds in a loan facility (through Slovenian Investment Bank - SID bank loan fund financial engineering, adding €12,5 million). In total, €185 million of financial support is available for energy renovation in the public sector, providing 40% grant financing for eligible projects.

There are several public support schemes for EE and EES related measures, administered by the Eco Fund:

- soft loans to legal entities (municipalities and/or providers of public utility services, enterprises and other legal entities) and sole traders for investments in environmental infrastructure, environmentally sound technologies and products, energy efficiency, energy saving investments, and use of renewable energy sources;

- soft loans to households for fuel switch from fossil fuels to renewable energy sources, energy saving investments, investments in water consumption reduction, etc.;
- grants to municipalities for investments in public buildings (schools, kindergartens, libraries etc.), newly constructed as low energy and passive buildings or renovated in passive standard; grants to households for investments in residential buildings (energy efficiency and use of renewable energy sources).

however, these funds are not available directly to EPC providers.

The most utilised financing models for energy efficiency are self-funding, loan financing, grant schemes, ESCO scheme, public-private partnership (PPP) and a combination of these (e.g. normally, projects in public buildings combine two financing models; the availability of EU structural and investment funds also help to combine financial schemes).
Models such as self-funding and loan financing are suitable for simple energy efficiency measures with short pay-back periods. Grant schemes are used for more complex projects, with longer pay-back periods. ESCO schemes and public-private partnership (PPP) are used for highly complex projects (administrative procedure complexity and need of capabilities of the public bodies), with moderate payback periods (up to 10 years).

Normally, energy performance contracting projects have a capital outlay of €1-5 million, a contract length of 11-15 years (due to prevailing buildings deep energy renovation), use a guaranteed savings model and are paid for using the provider's internal funds or debt arrangements and grant.

Financial incentives designed to support investment in energy renovation of old buildings and construction of new higher efficiency ones have been developed, as well as being financed through energy contracting.

Tax policy has also been shaped to incentivise businesses to finance and become involved in R&D programmes and demonstration projects. This will create competitive conditions for innovative research work in public companies. In order to achieve these results, Slovenia will be involved in European innovation promotion initiatives and projects with centralised EU funds in the area of climate-neutral society and the circular economy. Innovative financial schemes, such as PPPs, will be proposed as possible applications to support EE refurbishment of the social houses within the Slovenian SUPER-i pipeline.

2. Financial schemes: variable identification and data collection

The financial implementation of Super-i projects, see D3.3, was based on the work of Cappiello (2016) in investigating the financial impact of PPPs investment, and Carbonara & Pellegrino (2017) analysis of Win-Win financial schemes between PPPs partners.

In this section we describe the data collection process required to provide reliable financial analysis for each pilot. Our data collecting process consists of two parts:

1. Collecting primary financial data related to each pilot directly from the collaborating partners. These data are unique to each specific pilot such as the total cost investment, including the building cost, start-up cost, refurbishment cost and furnishing cost if available, the projected total revenue including operating revenues, projected income, and other sources of revenues, the projected total costs including operating costs, other costs, other expenses and interest expenses in case of financing is based on debt, and the funding sources including equity funding, debt funding, and other types of sources used to raise the necessary funds for each pilot.
2. Collecting secondary financial data from internationally reliable and accredited sources. These data are required to perform each evaluation method applied in D3.3 such as Net Present Value (NPV), Discounted Cash Flow (DCF), Net Cash Flow (NCF), Return on Investment (ROI), and the Cost-Benefit analysis.

According to the IEA, global Energy Efficiency (EE) schemes aim to achieve 20% reduction in CO2 emissions by 2030. However, in order to achieve this goal action is necessary in seven areas:

1. Cross-sector activity,
2. Buildings,
3. Appliances,
4. Lighting,
5. Transport,
6. Industry, and
7. Power utilities[2].

The main goal of the IEA is to support countries to save large quantities of energy at low cost, and addressing the financial barrier to EE investments such as availability of funds for investing in EE projects, information, awareness and communication, projected development and transaction costs, risk assessment and management, and the lack of capacity with respect to project developers and energy services companies (ESCOs), Local financing institutions, energy users, and risk managers, for more detailed discussion refer to D1.3.

One solution to overcome these barriers is through PPP funding mechanisms, which develop approaches to overcome the financing barriers by delivering benefits from the implementation of

[2] IEA, 2011

EE projects, such as expanded markets worth billions of euros for LFIs, increased competitiveness of economies, and significant CO_2 emission reductions. Businesses and industrial enterprises (small, medium, and large) will benefit from reduction in their energy bills, leading to increased profitability. So will households, giving them more money to spend elsewhere.

To investigate the potential financial benefits of PPPs in the SUPER-i project in Denmark, Italy, and Slovenia, a comprehensive financial analysis is performed with a focus on profitability from benefits of cost savings in energy consumption and CO_2 emission. The evaluation methods used are discussed in detail in D3.3.

2.1. Primary Financial Data

As mentioned previously, the Primary Data for the three Denmark, Italy, and Slovenia was developed and provided by the partners in each country after discussions about the necessary data to apply the evaluation approaches for SUPER-i in each pilot.

2.1.1. Italy

The Italian Pipeline provided all the requested data for both schemes; Montasio 31, and Boito 5. The table below, provides the total floor area per m^2 (22,888, and 552.16), and the number of dwellings (251, and 16), which are necessary for Table 1 in D3.3 that summarises the key figures for each scheme. These two indicators are necessary to evaluate the investment required per unit, and m^2 for each scheme for more details see D3.3.

		Needed														
		Building Geometry														Energy Use Data
Building Name	Year	Total floor area (m2)	Number of dwellings per building	Energy Performance Certificate rating	Number of storeys	Ground Floor area (m2)	Storey height (m)	Building height (m)	Building depth (m)	Building width (m)	Roof Area (m2)	Description of Walls	Description of Windows	Description of Roof	Description of Floor	Heating Demand (kWh/m2)
MONTASIO 31	1976	22,888	251	F	8	3,552	2.7	27	350	10	3,552	Reinforced concrete frame and infill in brick blocks plastered on the inside and tiled with terracotta tiles on the	Double glazed, aluminium frames	pitched and the attic is not heated.	concrete and masonry	82.18
BOITO 5	1951	552.16	16	G	4	150	2.8	15	18	8.5	150	Stone in basement, hollow bricks in upper walls	Wood frames	Hipped, tiled	brick and concrete, just 16 cm high	131.09

Table 5. Building Geometry and Energy Use Data

The Table below, provides Investment related information, and the projected investment cost for Montasio 31 and Boito 5. This table reports the duration of each scheme (1 year, and 2 Years), the initial starting date of each scheme (2023), the building cost of each scheme (€3,379,000, and €1,598,000), and Total investment costs (€3,379,000, and €1,598,000). Also, according to our partners in Italy, the provided figures for Boito 5 are projected for the whole period of two years which led to dividing the given figures by two in the financial implementation of D3.3, to reflect on the costs of year 1 and year 2 separately where year 2 figures are discounted (at discount rate of 2.15%) to show the correct value of money.

General information				Investments Costs (discounted values to initial date)				
Building Name	Year	Initial date of refurbishment	Number of years	Building cost	Furnishings	Start-up costs	Changes in working capital	Total Investment Costs
MONTASIO 31	1976	2023	1	3,379,000				3,379,000
BOITO 5	1951	2023	2	1,598,000				1,598,000

Table 6. Investments Costs Data

The Table below, provides the operating costs and expenses data for both schemes. Note that the same approach discussed earlier applies for Boito 5 data where we divided the costs by 2 and discounted the second year's figures to reflect the correct value of money. This Table provide projected figures of maintenance costs (€356,600, and €20,390), operating costs (€60,240, and €3,840), other costs (€11,295, and €720), and other expenses (€84,336, and €5,376) based on the current year figures. Note these data reflect the total cash outflows for the two schemes during the projects period.

Operating costs and other costs **				Expenses		
Maintenance costs	Operating costs	Other costs	Total costs	Interest expenses	Other expenses	Total Expenses
356,600	60,240	11,295	428,135	0	84,336	84,336
20,390	3,840	4,560	28,790	0	5,376	5,376

Table 7. Operating costs and expenses data

The Table below provides Operating revenues and Incomes for each scheme. Note that the energy savings are provided in Cost-benefit analysis, which will be discussed in more details in the next subsection. This table reports the values of operating revenues (€444,000, and €27,500), other revenues (€206,000, and €10,790), other income (€64,000, and €6,500), and total operating revenues and incomes (€714,000 and €44,790). These data reflect the total cash inflows for the two schemes during the project's period.

Operating revenues and incomes				
Operating revenues	Other revenues	Interest income	Other income	Total Operating revenues and incomes
444,000	206,000		64,000	714,000
27,500	10,790		6,500	44,790

Table 8. Operating revenues and incomes

Lastly, the table below shows the funding related data for the two schemes. The table indicates that, the fundings is 100% Equity for both schemes where for Montasio 31 the funding source is 64% from National Grants, and 36% from the private savings of current owners of the 36% of dwellings in Montasio 31, while 100% funding from National Grants for Boito 5. Note that these data are used in the calculations of the Total Cash in Flows evaluation method, that is this funding is not repayable to the source, as National Grants are not considered as loans.

Funding		Type of funding source				
Equity	Debt	National grants	EU grants	Loans from financial institutions	Private savings	Other
100%		64%			36%	
100%		100%				

Table 9. Funding related data

2.1.2.Slovenia

The Slovenia Pipeline provided all the requests. The table below, provides the total floor area per m^2, and the number of dwellings, which are necessary for Table 6 in D3.3 that summarises the key figures for the scheme. These two indicators are necessary to evaluate the investment required per unit, and m^2 for more details see D3.3.

Building Geometry									
Total floor area (m2)	Number of dwellings per building	Energy Performance Certificate rating	Number of storeys	Ground Floor area (m2)	Storey height (m)	Building height (m)	Building depth (m)	Building width (m)	Roof Area (m2)
1,806.0	26	F	4	439.00	4.20	16.70	12.96	33.20	790.00

Table 10. Building geometry data

The Table below, provides Investment related information, and the projected investment cost. This table reports the duration of the scheme (2 years), the initial starting date of the scheme (2022/2023), the building cost (€190,000), The start-up and other costs (€10,000), and the Total investment costs (€200,000). Also, according to our partners in Slovenia, the provided figures are projected for the whole period of two years which led to dividing the given figures by two in the financial implementation of D3.3, to reflect on the costs of year 1 and year 2 separately where year 2 figures are discounted (at discount rate of 1.99%) to show the correct value of money.

General information				Investments Costs (discounted values to initial date)				
Building Name	Year	Initial date of refurbishment	Number of years	Building cost	Furnishing	Start-up costs	working capital	Total Investment Costs
Neža 26 a in b	2005	2022/2023	2	190,000 €	0	10,000 €	0	200,000 €

Table 11. Investments Costs

The Table below, provides the operating costs and expenses data. Note that the same approach discussed earlier applies for the data where we divided the costs by 2 and discounted the second year's figures to reflect the correct value of money. This Table provide projected figures of maintenance costs (€200*24 months = €4,800), operating costs (€400*24 months = €9,600), other costs (NA), and Total Operating Costs (€14,400) based on the current year figures. Note these data reflect the total cash outflows for the two schemes during the projects period.

Operating costs and other costs				Expenses		
Maintenance costs	Operating costs	Other costs	Total costs	Interest expenses	Other expenses	Total Expenses
200€/month	400€/month	-	600€/month	0	0	0

Table 12. Operating costs and expenses data

The Table below provides Operating revenues and Incomes. Note that the energy savings are provided in Cost-benefit analysis, which will be discussed in more details in the next subsection. This table reports the values of operating revenues (€900*24 months = €21,600), and total operating revenues and incomes (€21,600). These data reflect the total cash inflows for the two schemes during the project's period.

Operating revenues and incomes					
Operating revenues	Energy savings	Other revenues	Interest income	Other income	Total revenues
900€/month (rents)		-	-	-	21,600€

Table 13. Operating revenues and Incomes

Lastly, the table below shows the funding related data. The table indicates that the fundings is 100% Equity with zero Debts, hence the funds are not repayable to a private entity. Note that these data are used in the calculations of the Total cash In Flows evaluation method.

Funding		Type of funding source				
Equity	Debt	National grants	EU grants	Loans	Private savings	Other
200,000.00 €	0	EKO Fund	-	-	100%	-

Table 14. Funding related data

2.1.3.Denmark

The Danish Pipeline failed to provide all the requested data for the different schemes as will be discussed in this subsection. The table below, provide the total floor area per m^2 (6,640, 1,293, 2,417, 2,919, 14,346, 2,557, and 2,417), and the number of dwellings (103, 16, 36, 40, 323, 29, and 30), which are necessary for Table 7 in D3.3 that summarises the key figures for each scheme. These two indicators are necessary to evaluate the investment required per unit, and m^2 for each scheme for more details see D3.3.

Development Name	Building Name	Year	Total	Number
Housing Areas Børglumparken		1986-89	6,640	103
Fruehoejgaard Social Housing Company	Afdeling Søndergade	1904-1917	1,293	16
	Vaevergaarden	1985	2,417	36
	Storgaarden	1993-2003	2,919	40
	Afdeling 9	1993-2003	14,346	323
	Hammerthor	2003	2,557	29
	Frisenborgparken	1989	2,417	30

Table 15. Buildings data

The Table below, provides Investment related information, and the projected investment cost for all the schemes. This table reports the duration of each scheme (6 months), the initial starting date of each scheme (2023, and 2024 for Afdelling Sindergrade), and the total investment costs for each scheme (DKK 5,930,000, 2,848,475, 2,246,678, 4,874,888, 8,939,920, 313,840, and 2,125,638). Note that these values are in DKK, and in D3.3. financial implementation was transferred to €using the current exchange rate between DKK and EUR.

Development Name	Building Name	Year	Initial date of the refurbishment	Number of years	Building cost	Furnishings	Start-up and other costs	Changes in working capital	Total Investment Costs
Housing Areas Børglumparken		1986-89	1/6/2023	0.5 year	na	na	na	na	5,930,000
Fruehoejgaard Social Housing Company	Afdeling Søndergade	1904-1917	1/6/2024	0.5 year	na	na	na	na	2,848,475
	Vaevergaarden	1985	1/6/2023	0.5 year	na	na	na	na	2,246,678
	Storgaarden	1993-2003	1/6/2023	0.5 year	na	na	na	na	4,874,888
	Afdeling 9	1993-2003	1/6/2023	0.5 year	na	na	na	na	8,939,920
	Hammerthor	2003	1/6/2023	0.5 year	na	na	na	na	313,840
	Frisenborgparken	1989	1/6/2023	0.5 year	na	na	na	na	2,125,638

Table 16. Investment related information

The Table below, indicates that the current funds don't cover the total cost of investments in each scheme, and that these available funds are repayable, therefore considered to be loans. Also, the gap between the current total investment costs and the available funds will be covered by own financing.

Denmark		Retrofit Business Case								
Development	Building Name	Retrofit Budget/Cost	Existing funding (DKK)	Type of financing	Payback	Increase in rent already	If not in place, would an	Extra funding: Possible	Would an increase in	How often can you
Housing Areas	Børglumparken	5,930,000	4,280,000	ESCO+own financing	32 years	No	Yes	Own financing	Yes	Often as needed
Fruehoejgaard Social Housing Company	Afdeling Sønde	2,848,475	750,000	ESCO+own financing	59 years	No	Yes	Own financing	Yes	Often as needed
	Vaevergaarden	2,246,678	1,380,000	ESCO+own financing	41 years	No	Yes	Own financing	Yes	Often as needed
	Storgaarden	4,874,888	1,250,000	ESCO+own financing	22 years	No	Yes	Own financing	Yes	Often as needed
	Afdeling 9	8,939,920	2,100,000	ESCO+own financing	36 years	No	Yes	Own financing	Yes	Often as needed
	Hammerthor	313,840	313,840	ESCO+own financing	24 years	No	Yes	Own financing	Yes	Often as needed
	Frisenborgparke	2,125,638	600,000	ESCO+own financing		No	Yes	Own financing	Yes	Often as needed

Table 17. Retrofit business case

The Table below, provides the operating costs and expenses data for both schemes. This Table provide projected figures of maintenance costs (NA), operating costs (NA), other costs (NA), Interest expenses (DKK 1,197,453, 485,663, 761,861, 1,147,805, 5,6161,647, 1,429,368, and 456,628) which represent the payments of debt, and other expenses (DKK 4,087,923, 978,775, 1,184,306, 1,226,862, 6,886,368, 863,066, and 665,979). Note these data reflect the total cash outflows for each scheme during the project's period.

Operating costs and other costs				Expenses		
Maintenance costs	Operating costs	Other costs	Total Operating costs and other costs	Interest expenses	Other expenses	Total Expenses
				1,197,453	4,087,923	5,285,376
				485,663	978,775	1,464,438
				761,861	1,184,306	1,946,167
				1,147,805	1,226,862	2,374,667
				5,616,647	6,886,368	12,503,015
				1,429,368	863,066	2,292,434
				456,628	665,979	1,122,607

Table 18. Operating costs and expenses data

The data for the Operating Revenues, Other revenues, interest income, other income, and the total operating income which are essential for the application of the evaluation methods discussed above will be provided in the coming deliverable D3.2.

The Table below, reports the Funding, and type of funding resources. From this table, the Equity and Debt does not reflect the funds provided for the SUPER-i projects, as they are significantly larger than the funds needed to cover the total investment costs. Therefore, a better explanation and more accurate data from our partners in Denmark is required to understand these data, and fill the missing requested data to perform the financial analysis.

Funding		Type of funding source				
Equity	Debt	National grants	EU grants	Loans from financial institutions	Private savings	Suspension
84,524,010	81,402,716	0	0	0	0	3,121,294
13,463,754	11,795,470	0	0	0	0	1,668,284
22,750,362	21,713,997	0	0	0	0	401,628
36,450,542	35,175,874	0	0	0	0	1,274,668
207,457,974	205,030,009	0	0	0	0	2,427,965
34,126,609	33,366,137	0	0	0	0	759,673
17,005,607	16,603,748	0	0	0	0	401,913

Table 20. Funding and type of funding source

2.2.Secondary Financial Data

The secondary financial data were collected/extracted from internationally reliable and accredited sources such as Refinitiv database, Statista database, and data stream. For the implementation of the DCF, NPV, and NCF, a discount rate for each country is required, as well as the future price of natural Gas for year 2032, and year 2052 in order to project the future energy savings of the SUPER-i projects in each country, and lastly the future price of CO_2 emissions per tonnes in year 2032 and year 2052 for each country in order to project the money value today of projected savings in CO_2 emissions for the next 10 years, and 30 years for each country.

Note that, the main source of revenue for PPP partners are the excess savings in energy costs, as discussed above.

The following Table provides the future prices of Natural Gas in USD and EUR, for year 2032, and year 2052 where these future prices per MWh are obtained from statista.com. This Table also reports the future prices of CO_2 emissions prices for year 2032, and year 2052. However, we provide three different projected future prices according to three scenarios. The Voluntary market scenario assumes the offset market remains similar to how it looks today. All types of supply are permitted, including offsets that avoid emissions instead of removing them. The Hybrid scenario looks at a gradual evolution of the offset market, from the voluntary market today, to a removal-only market. Lastly, the Science Based Targets Initiatives (SBTI) scenario: limits supply to removal offsets like reforestation and nascent technologies such as direct air capture. Note that in the financial implementation of D3.3 we use the Hybrid Scenario as it is commonly used in the literature.

	10 YEARS(USD)	30 YEARS(USD)	10 Years (EUR)	30 Years (EUR)
NATURAL GAS PRICES (MWh)	4.5	6.91	4.365	6.7027
CO2 emissions prices				
Voluntary Market Scenario	11	47	10.67	45.59
Hybrid Scenario	48	99	46.56	96.03
SBTI Scenario	224	120	217.28	116.4

Table 21. Future prices of Natural Gas

Discount rate

The discount rate used in order to accurately calculate the value of money today, we use the central bank 30-year bond yield as the discount rate which is 2.15%, obtained from Refinitive and Datastream.

2.2.1.1.1. Italy

Cost-benefit data

The Table below was provided by the partners in the UK. This Table reports the cumulative energy savings in 10 years (6899.8 MWh, and 256.7 MWh), and 30 years (20699.3 MWh, and 20699.3 MWh) for Montasio 31 and Boito 5 respectively. It also reports the CO2 emission cumulative savings in tonnes for 10 years (1276.5 tonnes, 47.5 tonnes), and for 30 years (3829.4 tonnes, and 142.5 tonnes) for Montasio 31, and Boito 5 respectively.

ITALY	Energy savings (MWh)		CO_2 emission savings (tonnes)	
	10 years	30 years	10 years	30 years
Montasio 31	6899.8	20699.3	1276.5	3829.4
Boito 5	256.7	20699.3	47.5	142.5

Table 22. Cumulative energy savings and CO2 emission cumulative savings

Note that we use the NPV evaluation method to determine the correct value today of the Energy and CO2 emission savings for more details see D3.3.

2.2.1.1.2. Slovenia

The discount rate used in order to accurately calculate the value of money today, we use the central bank 30 year bond yield as the discount rate which is 1.99%, obtained from Refinitive and Datastream.

Cost-benefit data

The Table below was provided by the partners in the UK. This Table reports the cumulative Energy savings in 10 years (661 MWh), and 30 years (1983). It also reports the CO_2 emission cumulative savings in tonnes for 10 years (122 tonnes), and for 30 years (367 tonnes).

SLOVENIA	Energy savings (MWh)		CO_2 emission savings (tonnes)	
	10 years	30 years	10 years	30 years
Building 1	661	1983	122	367

Table 23. Cumulative energy savings and CO2 emission cumulative savings

Note that we use the NPV evaluation method to determine the correct value today of the Energy and CO_2 emission savings for more details see D3.3.

2.2.1.2.Denmark

The discount rate used in order to accurately calculate the value of money today, we use the central bank 30-year bond yield as the discount rate which is 1.58%, obtained from Refinitive and Datastream.

Cost-benefit data

The Table below was provided by the partners in the UK. This Table reports the cumulative Energy savings in 10 years (1415.5 MWh, 259.1, 513.9, 768.3 1464.1, 318.4, and 157.2), and 30 years (4246.5 MWh, 777.2, 1541.8, 2305, 4392.4, 955.1, and 471.7). It also reports the CO_2 emission cumulative savings in tonnes for 10 years (261.9 tonnes, 47.9, 95.1, 142.1, 270.9, 58.9, and 29.1), and for 30 years (785.6 tonnes, 143.8, 285.2, 426.4, 812.6, 176.7, and 87.3).

DENMARK	Energy savings (MWh)		CO_2 emission savings (tonnes)	
	10 years	30 years	10 years	30 years
Housing Areas Børglumparken	1415.5	4246.5	261.9	785.6

Afdeling Søndergade	259.1	777.2	47.9	143.8
Vaevergaarden	513.9	1541.8	95.1	285.2
Storgaarden	768.3	2305.0	142.1	426.4
Afdeling 9	1464.1	4392.4	270.9	812.6
Hammerthor	318.4	955.1	58.9	176.7
Frisenborgparken	157.2	471.7	29.1	87.3

Table 24. Cumulative energy savings and CO2 emission cumulative savings

Note that we use the NPV evaluation method to determine the correct value today of the Energy and CO_2 emission savings for more details see D3.3. Also, even by using the savings from Energy and CO_2 emission as the only cash inflows, the evaluation methods produced weird results, hence it was decided not to provide them until the requested data is provided by the Denmark pipeline.

3. Energy efficiency in social housing: variable identification and data collection

3.1. Technical (energy savings)

In OECD and non-OECD EU countries, social rental housing represents more than 28 million dwellings and, on average, around 6% of the total housing stock. Energy efficiency in social housing is the subject of a range of energy saving directives across EU countries, and features in their net-zero targets.

The SUPER-i project aims to enable:

- Identification of the optimal renovations to the social housing building stock for each member state (MS), through an understanding of the reduced energy use and carbon emissions and the associated cost savings.
- Implementation of those renovations through review of the available business models, support mechanisms for each MS.

To assess these, we will create a survey to allow users to provide the necessary information set - a draft version is shown in the annex. SUPER-i partners have been involved in the design of this template, and it has been sent to the social housing managers of the three SUPER-i pilots and completed. Additional questions have been introduced to the initial set as they will inform the upcoming further data gathering.

The pipeline schemes included in the SUPER-i project span a range of build standards, proposed improvements and climatic regions. The building fabric is to be improved through a range of upgrades to the walls, windows and roofs[3], so that the project has the opportunity to:

- Model the expected energy use reductions,
- Review candidate mechanisms for funding the improvements
- Follow the process of implementing the upgrades,
- Calibrate our modelling against real-world energy use data

In order to model the heating and cooling use of the pipeline buildings, we have:

- Defined a minimum set of data that allow us to model the energy use data for a given building, including the geometry, orientation, and build materials, see D3.3 for more details.
- Created a template, and a web form based on it, that allows users to convey this information to us, and any additional technical information they may have, e.g. EPC performance certificate data.

[3] Further retrofits will increase the comfort of the stock through improvements to the lighting, air flow, though these will not affect the annual heating and cooling demand.

- Built, tested and validated a model that returns heating and/or cooling demand for a given time period, using local weather data from the LARC API.

In the next project phase, we plan to provide a model as a tool that can be used by housing associations, which will increase our calibration dataset, as well as the impact of the tool.

3.1.1.Model Inputs

Producing model inputs from the pipeline data has been an iterative process in each of the 3 cases, with the model developed and calibrated in partnership with the project housing associations. Discussions with the stakeholders allowed us to understand what data and technical understanding of their building envelopes they have, and to create a mapping from those to the U-values, which allow us to model the thermal performance of the buildings.

3.1.1.1.Denmark

The data provided by the Danish pipeline are provided below. The data on the building fabric are qualitative, and we have used the CIBSE to derive U-values from these.

Building Name	Total floor area (m2)	# dwellings per building	EPC rating	# storeys	Ground Floor area (m2)	Storey height (m)	Building height (m)	Building depth (m)	Building width (m)	Roof Area (m2)
Housing Areas Børglumparken	6,640	103	D	3	2,213	3	7.5			
Afdeling Søndergade	1,293	16	D/E	3	431	2.50	7.5	18	24	431
Vaevergaarden	2,417	36	C	3	806	2.50	7.5	16	49	806
Storgaarden	2,919	40	C	3	973	2.50	7.5	17	57	973
Afdeling 9	14,346	323	B/C/D			2.50	-	13	-	-
Hammerthor	2,557	29	B	2	1,279	2.50	5.0	19	68	1,279
Frisenborgparken	2,417	30	C	1	2,417	2.50	2.5	18	135	2,417
Afdeling 20 Hvalpsundvej, Aalborg	12,584	164	C	1-2	8,500	3.00	7.0	11	773	10,000
Afdeling 21, Næssundvej, Aalborg	16,276	202	E	1-2	11,000	3.00	7.0	9	1,222	13,000
Afdeling 23, Vildsundvej, Aalborg	10,370	145	D	2	7,000	3.00	7.0	9	778	8,000
Afdeling 24, Oddesundvej, Aalborg	15,507	186	C	1-2	10,500	3.00	7.0	11	955	12,000
Afdeling 40, Fredrik Bajersvej, Aalborg	11,698	137	C	1-2	7,500	2.75	7.0	10	750	9,000
Afdeling 35, Runddyssen, Svenstrup	11,242	131	C	1-2	8,000	3.00	7.0	8	1,000	9,000
Afdeling 36, Runddyssen, Svenstrup	13,771	175	C	1-2	9,000	3.00	7.0	8	1,125	10,500
Afdeling 37, Hellekisten, Svenstrup	7,750	114	B	2	4,000	3.00	7.0	9	444	5,000

Building Name	Description of Walls	Description of Windows
Housing Areas Børglumparken		
Afdeling Søndergade	125 mm rockw.	2-layer thermo
Vaevergaarden	125 mm rockw.	2-layer thermo
Storgaarden	100 mm rockw.	2-layer thermo
Afdeling 9	125 mm rockw.	2-layer thermo.
Hammerthor	125 mm rockw.	2-layer thermo
Frisenborgparken	125 mm rockw.	2-layer thermo
Afdeling 20 Hvalpsundvej, Aalborg	Exterior walls are made of approximately 280 mm thick concrete sandwich elements with grooves surface. Elements consist of approx. 100 mm back plate, 125 mm insulation and 55 mm front plate, according to the drawing materials.	Windows are wood / aluminum elements fitted with 2-layer energy windows with warm edges from 2009
Afdeling 21, Næssundvej, Aalborg	Exterior walls consist of 300-325 mm cavity walls with bricks in the facade and with full-wall rear wall elements. The cavity is insulated with 75-100mm according to the drawing material.	Windows are wood / aluminum elements fitted with 2-layer energy windows with warm edges from 2011
Afdeling 23, Vildsundvej, Aalborg	Exterior walls are predominantly consisting of approximately 325 mm cavity walls with bricks in the façade and with full-wall rear wall elements. The cavity is insulated according to the drawing material with 75-100 mm insulation.	Windows are wood / aluminum elements fitted with 2-layer energy windows with warm edges from 2010.
Afdeling 24, Oddesundvej, Aalborg	Exterior walls are made as approx. 280 mm thick concrete sandwich elements with groove surface. Elements are according to the drawing material consisting of approx. 100 mm back plate, 125 mm insulation and 55 mm front plate.	Windows are wood / aluminum elements fitted with 2-layer energy windows with warm edges from 2009
Afdeling 40, Fredrik Bajersvej, Aalborg	Exterior walls are made as a 310 mm cavity wall. Walls consist externally of brick and inside of aerated concrete. The cavity is insulated with 100 mm mineral wool according to the drawing material.	Windows are wood / aluminum elements fitted with 2-layer energy windows from 2006
Afdeling 35, Runddyssen, Svenstrup	Exterior walls are made as a 310 mm cavity wall. Walls consist of bricks and inside of aerated concrete. The cavity is insulated with 100 mm mineral wool according to the drawing material.	Windows and patio doors / lots are plastic elements fitted with 2-layer double glazing
Afdeling 36, Runddyssen, Svenstrup	Exterior walls are made as a 310 mm cavity wall. Walls consist externally of brick and inside of aerated concrete. The cavity is insulated with 100 mm mineral wool according to the drawing material.	Windows and patio doors / lots are plastic elements fitted with 2-layer double glazing
Afdeling 37, Hellekisten, Svenstrup	Exterior walls consist of approx. 310 mm thick walls with 100 mm rear wall lightweight concrete and 110 mm brick formwork. Exterior walls are according to the drawing material insulated with approx. 100 mm insulation between front and rear wall.	Windows are wood / aluminum elements mounted with 2-layer energy windows with warm edges.

Building Name	Description of Roof	Description of Floor
Housing Areas Børglumparken		
Afdeling Søndergade	175 mm rockw.	150 mm leca (lightweight expanded clay aggregate)
Vaevergaarden	200 mm rockw.	125 mm leca
Storgaarden	200 mm rockw.	150 mm leca
Afdeling 9	250 mm rockw.	260 mm leca
Hammerthor	250 mm rockw.	160 mm polystyren
Frisenborgparken	200 mm rockw.	50 rock+150 leca
Afdeling 20 Hvalpsundvej, Aalborg	Roof constructions are made as lattice rafter construction with roofing existing of corrugated asbestos sheets. The roof slope is approx. 20 °. According to the drawing material, horizontal ceilings are insulated with 175 mm insulation	Floors / terrain decks are made as wooden floors on joists of 80 mm concrete. The terrain covered is insulated according to the drawing material with 170-210 mm Leca nuts under the concrete.
Afdeling 21, Næssundvej, Aalborg	Roof constructions are made as lattice rafter construction with roofing existing of corrugated asbestos sheets. The roof slope is approx. 40 °. Horizontal ceilings are insulated according to the drawing material with 200 mm insulation.	Floors / terrain decks are made as wooden floors on joists of 80 mm concrete. The terrain covered is insulated according to the drawing material with 170 mm Leca nuts under the concrete.
Afdeling 23, Vildsundvej, Aalborg	1 and 2 storey dwellings made as a lattice girder construction with roofing consisting of roofing felt with moldings, slope is ~35 °. Horizontal ceilings are insulated with 195 mm insulation, sloping ceilings are with 200 mm insulation	Floors / terrain decks are made as wooden floors on joists of 80 mm concrete. The terrain covered is insulated according to the drawing material with 170 mm Leca nuts under the concrete.
Afdeling 24, Oddesundvej, Aalborg	Roof constructions are made as lattice rafter construction with roofing existing of corrugated asbestos sheets. The roof slope is approx. 20 °. According to the drawing material, horizontal ceilings are insulated with 175 mm insulation.	Floors / terrain decks are made as wooden floors on joists of 80 mm concrete. The terrain covered is insulated according to the drawing material with 170-210 mm Leca nuts under the concrete.
Afdeling 40, Fredrik Bajersvej, Aalborg	Roof constructions are made as lattice rafter construction with roofing existing of corrugated eternit slabs. Roof slope is approx. 22 °. According to the drawing material, the ceilings are insulated with 170 mm insulation.	Wooden floors on joists of 80 mm concrete, partly as tile floors on screed / concrete. For wooden floors, the terrain deck is insulated with 50 mm insulation between joists, tile floors are insulated with 50 mm insulation below concrete.
Afdeling 35, Runddyssen, Svenstrup	Roof constructions are made as lattice rafter construction with roofing existing of corrugated eternit slabs. Roof slope is approx. 20 °. Horizontal ceilings are insulated with 170 mm insulation according to the drawing material.	Terrain decks / floors are made of concrete with screed floors and insulated with 50 mm mineral wool between joists.
Afdeling 36, Runddyssen, Svenstrup	Roof constructions are made as a lattice rafter construction with roofing existing of corrugated eternit slabs. Roof slope is approx. 20 °. Horizontal ceilings are insulated with 170 mm insulation according to the drawing material.	Terrain decks / floors are made of concrete with screed floors and insulated with 50 mm mineral wool between joists.
Afdeling 37, Hellekisten, Svenstrup	Roof constructions are made as lattice rafter construction with roofing existing of corrugated asbestos sheets. Roof slope is approx. 45 °.	Floors / terrain decks are made as wooden floors on joists of 80 mm concrete. According to the drawing material, the terrain deck is made with 50 mm insulation over concrete and 150 mm capillary-breaking layer under the concrete

A range of upgrades are proposed across these 3 schemes, comprising 15 buildings. 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, and no specific choice of window model or supplier have been made. We have calculated the thermal improvement associated with upgrading the windows to a U-value of 0.8W/m^{2}K, at the upper end of triple-glazing performance.

3.1.1.2. Italy

The Italian pipeline comprises 2 schemes, Montasio and Boito. Montasio is a development of 251 units across 3 buildings, and Boito - a development of eight 16-unit towers. The latter scheme will be completely rebuilt, making comparison with the previous buildings harder than in the other cases, as the building geometry will be significantly altered - in particular, the new units will be twice the size of the old ones. However, as the exteriors of the buildings will be largely unchanged, meaningful savings can be calculated.

Building Name	Year	Total floor area (m2)	# dwellings per building	EPC rating	# storeys	Ground Floor area (m2)	Storey height (m)	Building height (m)	Building depth (m)	Building width (m)	Roof Area (m2)
MONTASIO 31	1,976	22,888	251	F	8	3,552	2.7	27	350	10	3,552
BOITO 5	1,951	552	16	G	4	150	2.8	15	18	9	150

Building Name	Description of Walls	Description of Windows	Description of Roof	Description of Floor
MONTASIO 31	Reinforced concrete frame and infill in brick blocks plastered on the inside and tiled with terracotta tiles on the outside. The thickness of the perimeter wall delimiting the air-conditioned rooms from the outside is 45 cm	Double glazed, aluminium frames	pitched and the attic is not heated.	concrete and masonry
BOITO 5	Stone in basement, hollow bricks in upper walls	Wood frames	Hipped, tiled	brick and concrete, just 16 cm high

3.1.1.3. Slovenia

In Slovenia, the pipeline consists of 2 buildings comprising 10 living units. These are to have their exteriors renovated and better performance windows installed, as well as energy-efficient lighting fitted. We have also considered the benefits of improving the thermal performance of the concrete floors.

Building Name	Year	Total floor area (m2)	# dwellings per building	EPC rating	# storeys	Ground Floor area (m2)	Storey height (m)	Building height (m)	Building depth (m)	Building width (m)	Roof Area (m2)
Neža 26 a in b	2005	1806	26	F	4	439	4.2	16.7	12.96	33.2	790

Building Name	Description of Walls	Description of Windows	Description of Roof	Description of Floor
Neža 26 a in b	Brick. In the apartments the partitions are brick, thick 10 and 20 cm, and the walls between the flats and towards the corridor are made of brick blocks 38 cm thick or prefabricated structures from gypsum boards 20 cm thick.	PVC, double glazing, good fittings	The construction of the roof over the attic is sloping, the sloping roof is insulated with thermal insulation made of glass wool.	reinforced concrete floor

SUPER-i

3.2. Life Cycle Assessment (LCA) and Social Life Cycle Assessment (SLCA)

The life cycle assessment (LCA), life cycle cost (LCC) and social life cycle assessment (SLCA) are methodologies that enable social housing owners and other stakeholders to understand the environmental, economic and social benefits and drawbacks of the refurbishment and renovation social housing strategies. They provide a framework for evaluating the impacts of building renovation projects across their entire life-cycle, towards informed decision-making and sustainable building practices.

LCA Methodology

The LCA methodology is usually used to evaluate the environmental impacts of each of the stages under consideration, e.g.: material extraction and production, construction, use and end-of-life disposal. The standard UNE-EN 15643 -Sustainability of construction works - Framework for assessment of buildings and civil engineering works" provides the requirements and methodology to assess the environmental, social and economic impact of buildings, applying to any construction work for their whole life cycle, with quantifiable indicators. The objective of LCA is to determine the impacts generated by the assets and facilitate the decision making process to stakeholders involved, specifically when choosing the energy efficiency measures, materials, and design of the building. It also serves as a reference for communicating and demonstrating the impacts analysed (environmental, economic and social).

3.2.1. LCA application in Buildings in Denmark

Historical Context and Development

In Denmark, environmental awareness in construction and the consequent performance of LCA in buildings was born in 2000, when the Danish Building Research Institute (SBI) developed the BEAT model (Building Environmental Assessment Tool), which consisted of a database for the systematic storage of all quantifiable environmental data, and an inventory tool for the calculation of potential environmental effects for buildings and construction elements[4].

Subsequently, in 2012, a building LCA version of the DGNB certification scheme was adopted, followed by a government strategy in 2014[5] to encourage the use of environmental assessment of buildings. This led the national construction authorities to develop a new tool, LCAbyg, which was launched in 2015.

---

[4] Freja Nygaard Rasmussen, Sara Ganassali, Regitze Kjær Zimmermann, Monica Lavagna, Andrea Campioli & Harpa Birgisdóttir (2019): LCA benchmarks for residential buildings in Northern Italy and Denmark – learnings from comparing two different contexts, Building Research & Information, DOI:10.1080/09613218.2019.1613883

[5] The Danish Government. (2014). Vejen til et styrket byggeri i Danmark – Regeringens byggepolitiske strategi [Pathway for a strong building sector in Denmark – The government's strategy for construction policy]. Copenhagen

Objectives and features of LCAbyg

The primary aim of the development of the LCA tool was, first of all, to provide the Danish construction industry with a harmonised LCA tool for buildings, a tool that was free to use and could support the development of sustainable buildings in Denmark. Second, the goal of developing the tool was to present the complex results of a building LCA in a transparent way that helps users understand the impacts related to the life cycle of the building and the environmental consequences of choosing different construction types and materials. Therefore, an important part of the development of the tool was related to the communication of the method and the interpretation of LCA. LCA will be used in this document to address the first study of the EE measures proposed for the Danish pipeline.

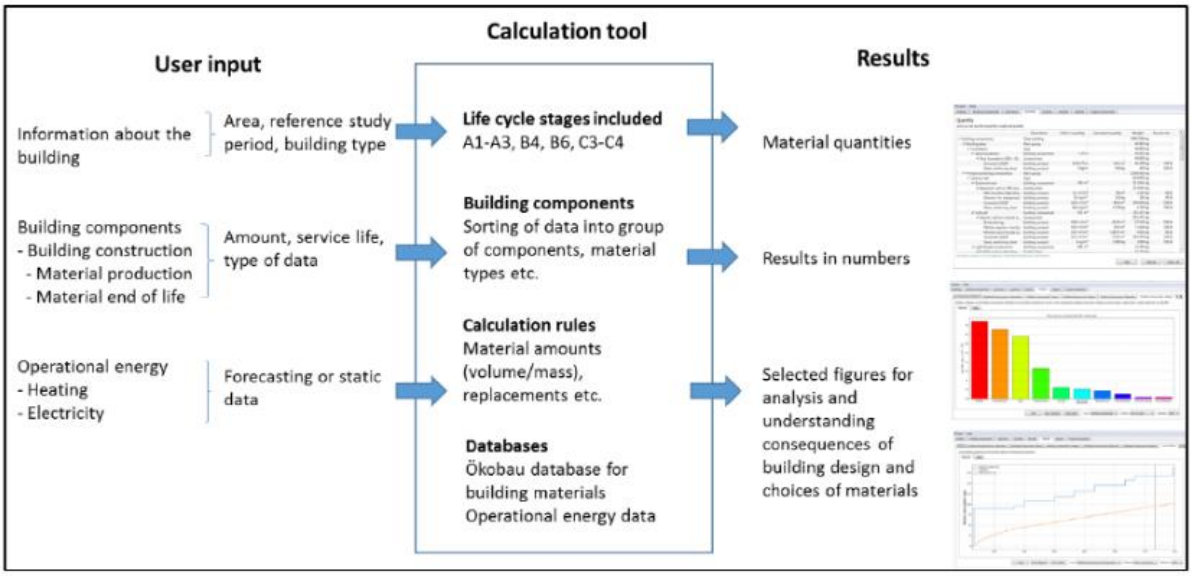

Figure 2 - The overall structure of LCAbyg tool[6]

Recent developments and future directions

Recent political focus has centred on developing a voluntary, sustainability building code as part of the building regulations (The Danish Government, 2018)[7]. LCA will form part of the environmental evaluation, and further development of LCA benchmarks will thus contribute with a scale for assessing a building's environmental performance.

- *Case Study: Windows*

The case of the Danish market for windows is exemplary regarding how regulation can determine the energy efficiency of construction products. In 2009, the authorities and the industry determined

[6] H Birgisdottir and F N Rasmussen 2019 IOP Conf. Ser.: Earth Environ. Sci. 290 012039

[7] The Danish Government. (2018). Strategy for the Circular Economy. Copenhagen. Retrieved from https://mfvm.dk/fileadmin/user_upload/MFVM/Miljoe/Cirkulaer_oekonomi/Strategi_for_cirkulaer_oekonomi.pdf

the desirable projection for the energy performance of windows specifying maximum values of net energy loss (result of the sum of heat loss and solar heat gain) for a window (facing southeast) of 1m^2 during a standard winter. The limits were set at maximum losses of 33 kWh for 2010, 17 kWh for 2015 and 0 kWh for 2020.

	Mandatory 2010	Class 2015	Class 2020
Maximum energy demand/year (residential) HFS is the building's heated floor space in m^2	52.5 kWh/m^2 + 1650 kWh/ HFS	30 kWh/m^2 + 1000 kWh/ HFS	20 kWh/m^2
Ditto (non-residential)[1]	71.3 kWh/m^2 + 1650 kWh/ HFS	41 kWh/m^2 + 1000 kWh/ HFS	25 kWh/m^2
Max. air leakage/second (test pressure 50 Pa)	1.5 l/m^2	1.0 l/m^2	0.5 l/m^2
Max. design transmission loss[2], single-storey	5 W/m^2	4 W/m^2	3.7 W/m^2
Min. energy gain[3] through windows/glazed walls	-33 kWh/m^{2}year	-17 kWh/m^{2}year	0 kWh/m^{2}year

1. Includes demand for lighting.
2. Average heat loss through 1m^2 of the non-transparent parts of the building envelope at 20˚C inside temperature and -12 ˚C outside.
3. Solar heat gain minus heat loss through 1 m^2 of window (facing south-east) during a standard Danish winter.

Table 25. Differences between Danish minimum requirements (Building Code of 2010) and those which apply to Class 2015 and Class 2020 buildings.

By 2020 the window's energy performance should be positive or zero. Despite initial concerns and protesst from manufacturers, these targets have been achieved by a pretty impressive margin. The best windows now not only achieve energy but also provide gains of 25 kWh/m^2. These efficient windows are only marginally more expensive than non-efficient windows, with the cost difference being offset by the additional energy savings.[8]

For life cycle assessment, this means that windows will only produce emissions in the production phases and that they could even reduce emissions in the operational phase by reducing the energy demand of spaces with windows, a fact that must be taken into account for modelling.

Once the material and type of glass are known, it will be possible to make a comparison of the reduction in emissions following the LCA model as shown in the figure below.

[8] Source: https://ens.dk/sites/ens.dk/files/Globalcooperation/tool_ee_byg_web.pdf

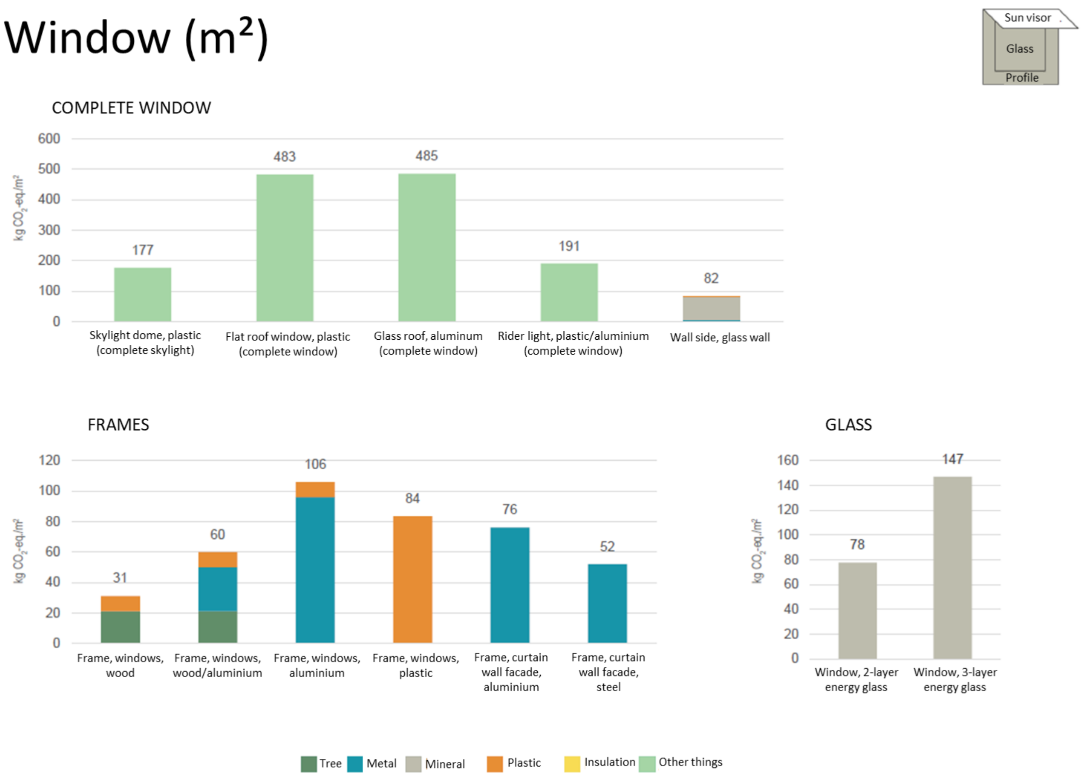

Figure 3. Typical results for windows in LCA[9]

- ### Case Study: Heating System

Reducing emissions from homes in Denmark requires a shift in focus around heat supply. Currently almost all multi-family homes and more than half of single-family homes are heated by heat networks.

In this sense, in recent years progress has been made through incentives for biomass, while also imposing taxes on other fuels. However, there is a potential for further improvement by incorporating renewable energy sources such as solar, aerothermal, and geothermal energy, which has the potential to supply 30% of Denmark's heating demand. Taxes have been introduced for the adoption of heat pumps and the replacement of diesel boilers with more sustainable sources of heat production.

[9] Source: https://build.dk/Assets/Eksempelbibliotek-til-LCAbyg/Layout-Version-Ren-21-01-22.pdf

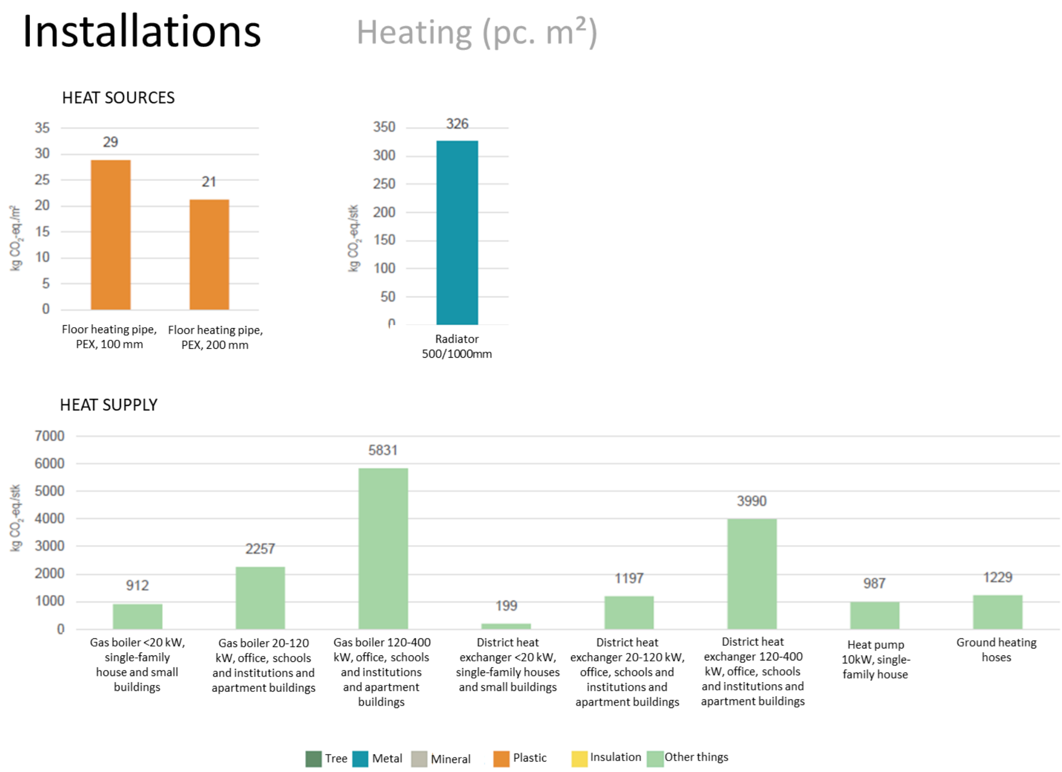

Figure 4. Typical results for heating installations in LCA[10]

3.2.2.LCA application in Buildings in Slovenia

Current state and efforts

In Slovenia, there is no established document for sustainable construction, not even at the level of recommendations, guidelines, or legislation, although related terminology appears in various strategic, operational and action documents. However, researchers recognize green building as a promising area and, from an operational point of view, experts follow EU developments around criteria for green building and industry and academia have joined the association to sustainable construction.

Around the evaluation of this, there are individual attempts that seek to evaluate different aspects of sustainable construction such as environmental, social, economic, or other indicators (such as ZKG10 or pilot evaluations of buildings within the European projects Open House, CEC5[11], EE-HIGHRISE). Different workshops and training have also been organised for experts, indicating a growing interest and commitment for which currently evaluation licences in private certification

[10] Source: https://build.dk/Assets/Eksempelbibliotek-til-LCAbyg/Layout-Version-Ren-21-01-22.pdf

[11] CESBA, https://www.cesba.eu/

schemes (LEED, DGNB). But the national-level advancement of building evaluations in the Slovenian market remains underdevelopment.

Challenges and future directions

Given the small size of the Slovenian market, international certification schemes are not widely adopted because they are not tailored to the Slovenian context and lack of comparability., The application of these schemes is of the interest of the stakeholders of the individual project and not so much of public interest. As a result, environmentally committed investors and large international corporations seeking sustainable building certificates to build in Slovenia.

In this regard, to follow the EU objectives in the field of green public procurement, the Government of the Republic of Slovenia issued the Regulation on Green Public Procurement (Green Public Procurement Regulation) at the end of 2011. Annex 7 of this regulation, which addresses buildings, including design, construction, regular and investment maintenance of buildings, as well as the installation and assembly of individual devices and products in the building, was largely based on green public procurement criteria from the European Directorate for the Environment. However, due to the complexity of green public procurement in the building sector has revealed that the same approach applied to green public procurement used for products does not work effectively for buildings.

Subsequently and in the same way, the Ministry of Environment and Space, together with other ministries, according to the decision of the Government of the Republic of Slovenia no. 00812-47/2012/13 formulated environmental or sustainable requirements for the design and construction of buildings, from which it was possible to consider the impact of the building throughout its useful life.

The proposal for a system of sustainable indicators should be reasonably based on the macro-objectives and the structure of indicators defined in the JRC study "Development of the EU framework of basic indicators for the evaluation of the environmental performance of buildings"[12]. Therefore, the Ministry commissioned the study "Review of sustainability criteria systems with transfer proposal"[13] (2016-2017) which is the basis for the development of an LCA criterion in buildings, still under development in Slovenia.

3.2.3. LCA application in Buildings in Italy

Historical context and development

Until 2018 there was no clear reference for the development of LCA for buildings in Italy[14].There were also no incentives for its use, and professionals only use LCA in exceptional cases, comparing

[12] https://susproc.jrc.ec.europa.eu/product-bureau/sites/default/files/2020-10/20201013%20New%20Level(s)%20documentation_1%20Introduction_Publication%20v1-0.pdf

[13] JN št. 430-144/2016

[14] Freja Nygaard Rasmussen, Sara Ganassali, Regitze Kjær Zimmermann, Monica Lavagna, Andrea Campioli & Harpa Birgisdóttir (2019): LCA benchmarks for residential buildings in Northern Italy and Denmark –

the results with other international reference LCA benchmarks, even though they were not calibrated for the Italian context. Consequently, Italian professionals could not compare the LCA benchmarks of different rating systems and the level of sustainability of buildings within a holistic framework because these benchmarks were related to specific rating systems and established through different methodologies, LCA system boundaries, and impact categories[15].

Introduction of ProCasaClima

Following the requirements of the European Directives (EU) 2018/844, 2010/31/EU and 2012/27/EU, together with the Climate Houses Directive, the ProCasaClima[16] software, was developed to calculate the energy efficiency of buildings.

ProCasaClima also facilitates the environmental impact assessment and the analysis of the life cycle of the materials, and consequently of the entire building, fundamental indices within the "CasaClima Nature" certification. The "Cost-Benefit Analysis" tool according to EN 15459-1 also allows the economic analysis of the effects of any improvement intervention.

Evaluation and future directions

The evaluation results in a quantitative building eco-index (Ieco) based on three indicators related to construction materials taken from the ProCasaClima materials database:

$$I_{eco} = \frac{1}{3} \cdot \left(\frac{1}{20} \cdot \left(\frac{PEI}{NFA} - 1000 \right) + \left(\frac{GWP}{NFA} + 50 \right) + 200 \cdot \left(\frac{AP}{NFA} - 0.3 \right) \right)$$

- Non-renewable primary energy demand (PEI) is expressed in MJ,
- Acidification potential (AP) expressed in kilogram of SO2 equivalent,
- Greenhouse potential (GWP100) is expressed as kilogram of CO2 equivalent (NFA, Net Floor Area [m2]). [17]

ProCasaClima will be used in this document to address the first study of the EE measures proposed for the Italian pipeline. The updated evaluation of ProCasaClima is currently being developed within the European FEDER BuildDOP project, with the main objective of producing an evaluation tool that guarantees optimal performance of the building from the design stages to operation.[18]

learnings from comparing two different contexts, Building Research & Information, DOI:10.1080/09613218.2019.1613883

[15] Ganassali, S., Lavagna, M., & Campioli, A. (2016). LCA benchmarks in building's environmental certification systems.

[16] Software CasaClima (agenziacasaclima.it)

[17] Santa U, Bancher M, Demattio M, Klammsteiner U. The CasaClima building assessment scheme: A key to design and construction quality, energy efficiency, and sustainability. ce papers. 2019;3:182–188. https://doi.org/ 10.1002/cepa.965

[18] New assessment of ProCasaClima software through BuildDOP project (1library.net)

4. Conclusions

Different member states face different challenges with the built environment, as they seek to create housing stock fit for contemporary living arrangements and reduce energy use, emissions and fuel poverty. Social housing accounts for 6% of homes across Europe, and as much as a quarter of residences in some member states. The Super-i project has developed a framework through which social housing schemes across Europe can assess the case for energy efficiency retrofit, and compare this against the local risk-free rate of return. This work is underpinned by a data template through which housing associations provide the information required to model the expected energy use for space heating in their developments. This template has been iteratively refined in consultation with the housing associations, and our results have, where possible, been validated against more detailed business case analyses, making the modelling tool potentially deployable for future improvement analyses for housing associations across Europe, subject to some model to cover the hosting, development and O&M costs of the tool.

The financial data collection, essential for accurate financial analysis, was divided into primary and secondary data collection. Primary financial data are gathered from our project partners in Italy, Slovenia, and Denmark. This data included critical financial metrics unique to each pilot project, such as total investment costs, projected revenues, operating costs, and funding sources.

- **Italy:** The Italian projects, Montasio 31 and Boito 5, provided detailed data on building geometry, investment costs, operating costs, revenues, and funding sources. This data enabled a thorough evaluation of investment per unit and per square meter.
- **Slovenia:** The Neža 26 a in b project in Slovenia supplied data on investment costs, operating expenses, and revenues, with figures adjusted to reflect accurate value over the project's timeline.
- **Denmark:** Despite partial data from Denmark, significant information on building geometry, investment costs, and funding sources was gathered. However, gaps in operating revenues and costs hindered the completion of a full financial analysis.

Secondary financial data was extracted from reputable international sources like Refinitiv, Statista, and Datastream. This data was crucial for implementing various financial evaluation methods, such as Net Present Value (NPV), Discounted Cash Flow (DCF), Net Cash Flow (NCF), Return on Investment (ROI), and Cost-Benefit Analysis (CBA). Key parameters included discount rates, future prices of natural gas, and projected CO2 emission prices, which are vital for projecting future energy savings and CO2 emission reductions.

The financial analysis of PPPs within the Super-i project in Denmark, Italy, and Slovenia focused on the profitability from cost savings in energy consumption and CO2 emissions. Our findings indicate significant potential financial benefits, including expanded markets for Local Financing Institutions (LFIs), increased economic competitiveness, and substantial CO2 emission reductions. Businesses and households are expected to benefit from reduced energy bills, leading to increased profitability and disposable income.

Using the methodologies of Life Cycle Assessment (LCA), Life Cycle Cost (LCC) and Social Life Cycle Assessment (SLCA) we can create robust framework for understanding the multifaceted impacts - environmental, economic and social - of social housing refurbishment and renovation strategies, allowing assessment of these impacts through the lifecycle of buildings and facilitating informed decision-making among stakeholders. The approach and implementation of these methodologies has been researched in the three countries involved in the project:

- Denmark has been at the forefront of integrating LCA into building practices since the early 2000s with the development of tools like the BEAT model and LCAbyg driven by regulatory frameworks and industry initiatives.
- In Italy the introduction of tools like ProCasaClima, aligned with EU Directives, marks a step towards integrating LCA in building assessments by facilitating environmental impact assessments and economic analyses.
- Slovenia has no comprehensive national framework for sustainable construction, but individual initiatives and compliance with EU directives indicate a growing commitment.

We found the need to harmonise and make LCA tools transparent is key across these countries. They should be accessible and user-friendly, but also capable of presenting complex environmental data so it can be easily interpreted by stakeholders. This will help to make informed decisions that balance environmental sustainability with economic feasibility and social responsibility.

Social Life Cycle Assessments (SLCAs) complement Life Cycle Assessments (LCAs) by assessing the social impacts associated with building life cycles, such as labour conditions, community impacts and social equity. The questionnaire developed during this project, and presented in *Annex 7.1* allows us to reach a more comprehensive understanding of the benefits and drawbacks of refurbishment strategies, ensuring that social dimensions are not overlooked in the pursuit of environmental and economic goals.

Our analysis of implementation of these methodologies in the pilot countries lead us to conclude that although Denmark, Slovenia and Italy are at different stages of integrating LCA and SLCA into their construction practices, they are all working toward more sustainable construction practices, and that each country demonstrates a commitment to improving building sustainability and energy efficiency in the social housing sector.

In future project stages, we will assess the energy savings associated with the implemented improvements and use the post-intervention energy use data to refine the model outputs. Additionally, we will perform a standardised LCA analysis on some of the building stock in the project to better evaluate the environmental impact and benefits of the renovations.

5. Annex

5.1. SUPER-i Survey draft

General

1. Building Name
2. Year of construction
3. Initial date of the refurbishment (if any)
4. Number of years (planned for carrying out the refurbishment)

Technical

1. Building geometry, including:
   a) Total building footprint
   b) Orientation
2. Dimensions, materials and insulating properties of the:
   a) Walls
   b) Roof
   c) Windows
   d) Floors
3. Proportion of the N,S,E,and W walls and roof which are glazed (covered in windows)
4. Number of dwellings
5. Number of storeys
6. Total floor area

Financial

Investments Costs (discounted values to initial date)

1. Building cost
2. Refurbishment cost (windows, wall insulation, etc..)
3. Furnishings
4. Start-up and other costs
5. Changes in working capital

Operating costs and other costs

6. Maintenance costs
7. Operating costs
8. Other costs
9. Operating costs and other costs
10. Interest expenses
11. Other expenses
12. Operating revenues
13. Other revenues
14. Interest income
15. Other income

Funding

16. Equity
17. Value of the buildings plus cash flows for EE refurbishment*
18. Debt

Type of funding source

19. National grants
20. EU grants
21. Loans from financial institutions
22. Private savings
23. Other (Y/N)
24. If Yes, what is the percentage increase? %

Environmental

Scope

1. Service lifespan, for environmental impact purposes? Default: 50 years
2. Life cycle stages to be taken into account when making the performance assessment

Use stage consumption

3. Energy use (in kWh/m^2/yr) - this may be available in the EPC certificate.
   a) Primary energy demand
   b) Delivered energy demand
      I. Heating Demand (kWh/m^2):
      II. Hot Water Demand (kWh/m^2):
      III. Cooking Demand (kWh/m^2):
      IV. Cooling Demand (kWh/m^2):
      V. Ventilation Demand (kWh/m^2):
      VI. Electricity Demand for Appliances (kWh/m^2):
      VII. Lighting Demand (kWh/m^2):
4. Water consumption in use phase (l/m^2/year)
5. Energy Performance Certificate rating (if available)

Buildings components (elements, structural parts, products, materials) needed during its lifetime.

6. Structural components
   a) Floor -> materials (type and quantity in kg)
   b) Roof -> materials (type and quantity in kg)
   c) Walls -> materials (type and quantity in kg)
   d) Windows and doors -> materials (type and quantity in kg)
   e) Any other structural part (please specify) -> materials (type and quantity in kg)
7. Energy systems
   a) Heating system -> materials (type and quantity in kg)
   b) Hot water system -> materials (type and quantity in kg)
   c) Ventilation system -> materials (type and quantity in kg)
   d) Air conditioning -> materials (type and quantity in kg)
   e) Lighting -> materials (type and quantity in kg)
   f) Renewable Energy Sources -> materials (type and quantity in kg)

8. If any of the previous components need maintenance or replacement during the building life span please specify which components, frequency of maintenance or replacement and materials (type and quantity) to maintain or replace.

Resource efficient and circular material life cycles

9. Energy efficiency improvements -> materials (type and quantity in kg)
10. If any of the previous components need maintenance or replacement during the building life span please specify which components, frequency of maintenance or replacement and materials (type and quantity) to maintain or replace.
11. Are there any of the components of the building recycled, reused material? Please specify component, material and kg

Efficient use of water resources

12. Water consumption improvements -> materials (type and quantity in kg)
13. If any of the previous components need maintenance or replacement during the building life span please specify which components, frequency of maintenance or replacement and materials (type and quantity) to maintain or replace.

End of life

14. Waste management for materials for dismantling or demolition (including deconstruction, dismantling and demolition):
    a) for reuse -> materials (type and quantity in kg)
    b) recycling -> materials (type and quantity in kg)
    c) other valorisation alternatives (please specify) -> materials (type and quantity in kg)
    d) and waste disposal-> materials (type and quantity in kg)
    e) waste transportation for structural components and energy systems -> kms

Social

Accessibility

15. Is there parking accessible for special needs people?
16. Is there any picking up point for special needs people?
17. Is there any curb ramp to the entrance of the building?
18. Are there any accessibility measures to permit the entrance and the continuity of access and movements inside the building?

Health and comfort

19. Does the user have the possibility to access the temperature control of their home?
20. Does the user have the possibility to open the windows to improve the air quality of the dwelling?
21. Is there any ventilation system in the building?
22. Indoor air quality (Temperature, humidity, CO_2 concentration)

Energy poverty

23. % of total spent of residents in energy supplies, on average
24. % of total income of residents in energy supplies, on average
25. % of households unable to afford to keep their home adequately warm, on average

Loads for the neighbourhood including heat, noise, vibrations, including glare and light

26. Impact on the health and comfort of users during rehabilitation tasks
    Assess the possible impacts of these activities on:
    a) indoor air quality
    b) noise: intensity and duration
    c) thermal characteristics: temperature and humidity
    d) visual comfort
27. User safety during rehabilitation tasks
    Assess the possible impacts of these activities on:
    a) fire protection
    b) protection against intruders and vandalism
28. Ability to use the building (usability) while rehabilitation works are carried out

Safety

29. Is there any security lock system?
30. Are the steps clearly visible?
31. Barriers against deliberate traffic intrusion
32. Impact resistance of building envelopes to protect against vandalism
33. Protection of building enclosures against arson fires
34. Secure storage of waste to minimise the risks of vandalism/pyromania
35. Graffiti resistant surfaces
36. Alarm and surveillance systems, preferably connected to the police or other recognized agents
37. Motion sensitive lighting
38. Presence of backup equipment for heating and electricity
39. Free and safe movement within the building and evacuation from it, in the event of a power outage
40. Measures to use services manually in the event of a power outage

Stakeholders implication, including relations with local society and building end users

41. Communication effectiveness
42. Stakeholder support of project
43. Partnerships and collaborations
44. Mutual learning

Jobs creation

45. After the refurbishing are there any new jobs created?

6. References

Freja Nygaard Rasmussen, Sara Ganassali, Regitze Kjær Zimmermann, Monica Lavagna, Andrea Campioli & Harpa Birgisdóttir (2019): LCA benchmarks for residential buildings in Northern Italy and Denmark – learnings from comparing two different contexts, Building Research & Information, DOI:10.1080/09613218.2019.1613883

The Danish Government. (2014). Vejen til et styrket byggeri i Danmark – Regeringens byggepolitiske strategi [Pathway for a strong building sector in Denmark – The government's strategy for construction policy]. Copenhagen

H Birgisdottir and F N Rasmussen 2019 IOP Conf. Ser.: Earth Environ. Sci. 290 012039

The Danish Government. (2018). Strategy for the Circular Economy. Copenhagen. Retrieved from https://mfvm.dk/fileadmin/user_upload/MFVM/Miljoe/Cirkulaer_oekonomi/Strategi_for_cirkulaer_oekonomi.pdf

Uredba o zelenem javnem naročanju (Uradni list RS, št. 102/11, 18/12, 24/12, 64/12, 2/13, 89/14 in 91/15 – ZJN-3)

http://ec.europa.eu/environment/gpp/eu_gpp_criteria_en.htm

https://susproc.jrc.ec.europa.eu/product-bureau/sites/default/files/2020-10/20201013%20New%20Level(s)%20documentation_1%20Introduction_Publication%20v1-0.pdf

JN št. 430-144/2016

Freja Nygaard Rasmussen, Sara Ganassali, Regitze Kjær Zimmermann, Monica Lavagna, Andrea Campioli & Harpa Birgisdóttir (2019): LCA benchmarks for residential buildings in Northern Italy and Denmark – learnings from comparing two different contexts, Building Research & Information, DOI:10.1080/09613218.2019.1613883

Ganassali, S., Lavagna, M., & Campioli, A. (2016). LCA benchmarks in building's environmental certification systems.

Santa U, Bancher M, Demattio M, Klammsteiner U. The CasaClima building assessment scheme: A key to design and construction quality, energy efficiency, and sustainability. ce papers. 2019;3:182–188. https://doi.org/ 10.1002/cepa.965

7. Acronyms

BL: Boligselskabernes Landsforening
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
GHG: Greenhouse Gas
GPP: Green Public Procurement
HFRS: Housing Fund of the Republic of Slovenia
IEA: International Energy Agency
LCA: Life Cycle Assessment
LCC: Life Cycle Cost
MS: Member State
NCF: Net Cash Flow z
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