Deliverable 5.2
Case studies results

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DoA	This document provides the analysis of the real application of the promising Business Models identified in Task 5.1 within real business cases. The Business Cases (BC) represent the successful deep refurbishment of low energy buildings by mean of proposed innovative technologies and/or business models. As such, a detailed analysis of these BC have been performed with the aim of evaluating and highlighting their distinctive elements as well as their common features towards potential optimization and, if possible, wider replication.				
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Contents

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EXECUTIVE SUMMARY

This report has been prepared in the framework of WP5 “Promotion of new business models and validation through business cases” of STUNNING project “SusTainable bUsiNess models for the deep renovation of buIldiNGs” (GA: 768287).

The focus of this report is the **analysis of the real application of the promising Business Models identified** in Task 5.1 within real Business Cases (BC). These Business Cases represent the successful deep refurbishment of low energy buildings by mean of proposed innovative technologies and/or business models. As such, a detailed analysis of these BC have been performed with the aim of evaluating and highlighting their **distinctive elements as well as their common features** towards potential optimization and, if possible, to deduce **general recommendations** giving the possibility to identify replicable and adaptable models of business, representative of the typical needs of refurbishment activities.

Previous project activities lead to the identification of the four families of most promising business models in correspondence of the European area in which they are currently applied and they present the higher grade of replicability. Then, activities carried out focused on the research and collection of potential BC to be selected considering both climate and building stock characterizations, based on which ensure their capacity to foster the achievement of European geographical coverage target towards the increase of 2-3 % buildings’ renovation.

In this context, a limited number of Business Cases, at least ten, have been provided. As innovation is often introduced in the market by mean of R&D projects, most of the BC identified were **“pilot demonstrators”** of past or ongoing EU projects (EeB or Smart Cities), where the related innovative Refurbishment Package (RP) or Business Models (BM) has been developed and applied in a real environment.

Then, Business Cases identified have been deeply described, analysed and evaluated towards the development of distinctive elements as well as common features that can be translated into recommendations for the Business Model widespread adoption, including:

- Recommendations on strategies to improve the user behaviour through stronger engagement of users in the refurbishment programs, fostering a motivation for changing the user demand profile, according to the business model designed by the investors
- Recommendations on improvement of public procurements models to enhance the SMEs participation in energy efficient rehabilitation of public buildings and neighbourhoods.
- Recommendations on patterns, replicable models and conditions for potential (or evidence for) failure and success, associated to the models, the end applications and the geographical boundaries of interest.

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INTRODUCTION

This document constitutes the deliverable D5.2 “Case studies results” of the STUNNING project “SusTainable bUsiNess models for the deep renovation of bulldiNGs” (GA: 768287). It reports the activities carried out in the framework of the identification and evaluation of the achievements obtained through the application of the selected promising Business Models within the selected case studies.

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1. Background and methodology

1.1. Project background

40 to 45% of Europe's energy consumption comes from buildings with a further 5-10% required for the manufacturing and transport of construction products and components. As such, the building sector is one of the key enablers for achieving 2050 low carbon economy goals. Only 1 to 2% of the building stock is replaced annually in the EU[1], hence most of the energy savings required to meet Europe 2050 goals must come from existing buildings. However, **today's measured rate of refurbishment (1.2%) is much lower than the one which should be observed to remain in line with Europe 2050 ambitions**. There is a need to accelerate the market uptake and large-scale implementation of energy efficient refurbishment solutions and increase the renovation level to 2-3% per year until 2030. This ambition is reflected in several European regulations and roadmaps, such as the Energy Performance of Building Directive (EPBD), the Energy Efficiency Directive, the SET-Plan (Action 5) and the recent Energy Union Winter Package.

In addition to this, the European building sector is still highly fragmented and not yet able to offer holistic solutions for existing buildings' deep renovation at acceptable cost and quality. The building process usually involves multiple separated disciplines and players, which leads to additional costs and risk of failure[2]: integration is critical. **Additionally, the renovation market is principally supply-driven, which can lead to a mismatch between the offered products and the end users' needs.** Nevertheless, a number of non-technical stakeholders also influences decision making in building renovation. Municipalities, local authorities and local energy/building renovation agencies are for example instrumental in the achievement of the EU renovation targets, especially when addressing the optimal integration of RES[3], which requires planning, and implementation at a district scale. There is a need to increase awareness of commitment to improved energy-efficiency of the building stock, and to increase the capacity of municipalities to promote and assist the renovation of building stocks, in particular through the use of public procurement tools.

In this context, the European Commission within the HORIZON 2020 framework programme (call EEB-08-2017 New business models for energy-efficient buildings through adaptable refurbishment solutions") has funded the STUNNING project. Its overarching goal was that of "engaging with the whole community of stakeholders and accelerating the adoption of new business models for energy-efficient buildings based on integrated, adaptable and affordable refurbishment packages, which will contribute to reaching the targeted EU renovation rate".

Indeed, with the involvement of a comprehensive stakeholders community (including industrials and SMEs from the construction sector, energy utilities, capital providers, municipalities, building owners, tenants, research institutes), STUNNING aims to accelerate the adoption and large scale replication of new business models in order to meet the building renovation rate set by the upgraded EPBD. Under the coordination of DOWEL, five players (CSTB, RINA, Solintel and Steinbeis 2i GmbH, all key active members within the ECTP) propose a systemic and integrated approach to address the market rollout of innovative refurbishment

[1] Boosting Building Renovation: What Potential and Value for Europe? – Study for the ITREE Committee – 2016 - Directorate General For Internal Policies Policy Department A: Economic And Scientific Policy

[2] EASME (2016) Energy Efficiency – Building Renovation Challenge: Practical Approaches

[3] RES: Renewabvle Energy Sources

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packages, supported by an Advisory Board covering the whole refurbishment value chain. The five project objectives are aligned with all the EEB-08-2017 call challenges:

- Supporting the cooperation of diverse, yet dispersed, stakeholders federated in a single stakeholder community built around a web-based knowledge sharing platform addressing technologies and business models for refurbishment in EU28;
- Benchmarking and (geo)clustering innovative refurbishment packages and ranking them according to profitability / energy efficiency indicators;
- Identifying and addressing barriers which still prevent these refurbishment packages from being replicated by value chain players;
- Promoting and validating (through real business cases) novel renovation business models allowing consumers and the market to invest with confidence, thanks to performance-guaranteed energy savings, and addressing end user's commitment to energy efficiency after renovation;
- Disseminating the support action outputs, with an exploitation strategy for the newly built knowledge-sharing platform, thus continuing to interact with the stakeholders' community beyond the completion of the STUNNING project and contributing to maximising its impact and more globally the EEB PPP[4].

1.2. Approach towards the promotion of new business models and validation through business cases

In the framework of the STUNNING project, specific activities were dedicated to promote across Europe the implementation of innovative and original "refurbishment packages" including both an eco-efficient smart product or process for buildings' renovation and the related business model for its application.

To this aim, different kind of information gathered along the project have been used and reviewed accordingly.

In particular, the following analysis have been carried out within the project:

- Assessment and identification of the **main stakeholders of construction sector** with the aim of identifying their main needs and their role in the delivery of the specific renovation packages (both in the delivering of the technical solutions and in the implementation of the related business models);
- Evaluation of the **renovation packages** in order to evaluate the most relevant KPIs[5] and cost-benefits associated to them as well as the main building type for them to be put in practice in a cost effective way, also according to the country of application;
- Preliminary identification of **potential success stories** implementing promising refurbishment packages.

Based on this review, the following steps were set up towards the promotion of new business models:

1. **Identification and evaluation of innovative business models for dedicated key stakeholders**, with a two-fold aim. On one hand, that of creating a dedicated Business Models' (BM) DataBase (DB) to stimulate the collection of additional data and eventually to find potentially uncovered business cases and target markets, to define BMs clusters, and eventual data filling needs, etc. On the other hand, to select a limited number of basic criteria to be desumed, giving the possibility to identify replicable and adaptable models of business, representative of the typical needs into the refurbishment activities.

[4] Energy Efficiency Buildings Public Private Partnership

[5] Key Performance Indicators

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2. **Application of selected business models within real case studies** that will be selected covering different built environment.
3. **Promotion of the selected and validated business models** further analysed in order to find the most promising driving features for their wide scale replicability across Europe.

The focus of Deliverable 5.1 was the description of the methodology defined for performing Step 1 and the related main output in terms of Business Models' DataBase set up, business model clustering, definition of specific criteria for selecting the most promising business models, etc. Based on these activities, this report focuses on work performed for Step 2, to cover the last kilometers towards Step 3.

To this aim, the main activities performed were the following:

- **Business Cases identification**, based on the Business Model they are related to (at least one per BM), per geographical area and building typology.
- **Business Cases description**, by collecting the main info as detailed in Appendix 1.
- **Business case evaluation**, taking into account the following parameters:
  - Application of Business Model (it was applied as per state of the art or it was somehow tailored)
  - Any barriers encountered or market mechanism that particularly foster the BM application and its success
  - Main stakeholders involved
- **Business Cases main results**, in terms of recommendations, BM optimization, potential strategies towards replication, etc.

With respect to this report structure, Chapter 2 is related to the BC identification and short description while Chapter 3 is dedicated to the BC evaluation and analysis of main results.

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2. Business Cases' identification

In the framework of STUNNING project, the identification of proper Business Cases have been done to promote and validate the selected promising renovation business models, allowing consumers and the market to invest with confidence, thanks to performance-guaranteed energy savings, and addressing end-user's commitment to energy efficiency after renovation.

2.1. Approach towards Business Cases identification

The identification of Business Cases, where innovative refurbishment solutions and associated business models can be applied, have been performed taking into account the following aspects:

- The business cases **shall represent the most common building typologies** within the EU building stock. Indeed at the beginning of the project the primary targets were residential buildings and office buildings built in the 70-80' with curtain-wall or similar façade system, with a special focus on social housing.
- The business cases shall provide **evidence of application of innovative RP and BM**, and thus main references have been past or on-going EU projects (EeB or Smart Cities) where potential BC may be represented by the related "pilot demonstrators".
- The business cases shall be properly described collecting at least the following info (see template in Appendix 1):
    - Description
    - Small description
    - Involved stakeholders
    - Location
    - Environmental data
    - Information on local constraints / regulations / incentives
    - Building characteristics
    - Performance before
    - Performance after
    - Refurbishment package
    - Business model
    - Lessons learnt and guidelines for replication
    - Pictures
    - Useful links

In agreement with the STUNNING Consortium and the Advisory Board, the approach towards the identification of the Business Cases has been deeply discussed both internally to the consortium and with the Advisory Board. In line with the major scope of fostering the Business Models application and thus the buildings renovation in Europe, **business cases have been collected according to the climate zone they belong to and to the more widespread building typology**.

In this framework, there were some difficulties in the data gathering. Indeed, despite the wide network of project consortium as well as their participation in several EU project, sometime it was very difficult

- To find all the relevant data needed due to confidentiality reason or because info was not public,
- To have the right contact person in the project, since data was collected by a partner and the building owner was another one, or since the reference contact has been changed several times;
- To receive a proper feedback on the template properly filled in, especially for project already closed;

For these reasons, a relevant effort has been spent on data gathering and consolidation from different sources.

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2.2. Business Cases short description

The network of the project consortium as well as the activities performed in WP2 with respect to the identification of refurbishment packages in real buildings allow to identify a total of **14 Business Cases**, to be used to validate the most innovative Business Models and to find out potential recommendations as well as best practices towards their wider adoption.

The following table provides a global overwiew of the identified business cases while paragraphs below provide more details, shortly describing them according to the geographical context they belong to.

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Table 2.1: Summary of selected BC

Area	Climate	BC Code	City	Country	BM	Project	Type of building	Type of owner
Northen	Cold continental, with cold to mild summer	N1	Alingsås	Sweden	OSS - PPP	BEEM UP	Single Family Houses	Public
		N2	Stockholm	Sweden	Step by step	EUROPHIT	Multi family houses	Private
		N3	Oulu	Finland	Add on	E2REBUILD	Student Apartment	Public
Southern	Mediterranean	S4	Torrelago	Spain	EPC	CityFIED	Multi family houses	Private
		S5	Pieiria	Greece	EPC	ECOLISH	Social Housing Apartments	Public
		S6	Madrid	Spain	Step by step	EUROPHIT	Multi family houses	Public
Western	Temperate, with warm summer	W7	Hem	France	Energiesprong	E=0	Single family houses	Public
		W8	Delft	Netherland	OSS - PPP	BEEM UP	Multi family houses	Public
		W9	Paris	France	OSS - PPP	BEEM UP	Multi family houses	Public
		W10	Munich	Germany	Add on	E2REBUILD	Multi family houses	Public
		W11	Kroeven Roosendaal	Netherland	Add on	E2REBUILD	Single family houses	Private
		W12	Nottingham	UK	Energiesprong	Remourban	Social Housing Apartments	Public & Private
		W13	Graz	Austria	Add on	SQUARE	Multi family houses	Public
Eastern	Cold continental, with warm summer	E14	Gabrovo	Bulgaria	Step by step	EUROPHIT	School	Public

2.2.1. *Northern area*

The most promising Business models selected for the Northern area was Betterhome (see Appendix 2), belonging to the One-Stop-Shop Business Model category (type “OSS provided by digital tools”). The One-Stop-Shop business model aims at providing full service energy efficient renovation of mainly private single-family houses (in some cases also multi-family houses can be addressed) and it is particularly widespread in Nordic countries where there is plenty of these buildings’ types. In those countries the majority of the houses are more than 30 years old and need to be renovated[6], which provides opportunity for implementation of energy efficiency measures. Indeed, in the Nordic countries typical single-family houses with large primary energy saving potential are those from the 1960´s and 1970´s, since they were built in large numbers and built just before the tightening of the insulation standards in the late 1970’s, and because electric heating is prevalent (except for Denmark). These features, together with the positive results and potential of replicability of the proposed approach, permitted to select Betterhome as the most promising business model for the Northen area of EU. Nevertheless, due to confidentiality of data related to the project demo buildings, it was impossible to get on board Business Cases related to the application of this BM.

However, other Business Cases identified perfectly fit with the building typology that is more widespread in the Northern Area of Europe, namely residential buildings (apartments and single-family houses), while the related Business Models evaluated were always the One-Stop-Shop business model but based on Public Private Partnership, the Step-by-Step Approach as well as the Add-On Approach (see Appendix 2).

In particular, the following business cases have been identified in the Northern Area:

- **Multi-dwellings residential building**, located in Alingsås, **Sweden** and known as Brogarden, classified by the municipality as an area of conservation value. This business case represents the Swedish demonstration site of the BEEM-UP[7] project, a Public Private Partnership collaborative project that aimed to demonstrate the economic, social and technical feasibility of retrofitting initiatives for drastically reducing the energy demand in existing residential buildings, and lay the ground for massive market uptake of such initiatives. Overall, a gross floor area of 14860 m² has been refurbished in the project. The houses were stripped down to the frame and rebuilt using passive house techniques. While doing this, the layout of the apartments has been changed slightly to ensure better accessibility and to provide an increased number of large apartments that suit the modern way of living better than the old layout.
- **Typical detached villa from the 1950’s**, located in Stockholm, **Sweden**. This business case represents the Swedish demonstration site of the EUROPhit[8] project, aimed at widespread Passive House principles towards deep energy retrofits by mean of a Step-by Step approach. The building is a typical concrete block detached single-family house, serviceable, but not energy efficient. Parts of the building are not efficiently used either.
- **Student Apartment**, located in Oulu, **Finland**. This business case represents the Finnish

[6] One-stop-shop service for sustainable renovation of single-family house – Norden – Nordic Innovation Report 2012 - Krushna Mahapatra, Mid Sweden University

[7] http://www.buildup.eu/en/explore/links/beem-project-0 - Building Energy Efficiency for Massive market UPtake

[8] https://europhit.eu/ - Retrofitting for the energy revolution, one step at a time

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demonstration site of the E2ReBuild[9] project, aimed to investigate, promote, and demonstrate cost-effective and advanced energy-efficient retrofit strategies that create benefits for existing residential buildings. PSOAS Student Housing Foundation of Northern Finland owns the building, originally built in 1984, and it is one of five student apartment buildings in the housing cooperative. The student apartments were outdated and the building was in need of a complete refurbishment by mean of the Add-On Business Model.

2.2.2. *Southern area*

The most promising Business Models selected for the Southern area were Enerphit and EUROPACE.

The Enerphit approach permits to implement EE measures in successive steps, according to an initial planning using PassivHaus Components. Such an approach can be promising for the southern area according to different reasons: on one hand Mediterranean climate conditions allows the renovation project to tackle EE measures over a longer period of time, with minor consequencies on user's comfort; on the other hand the project can be managed with a low budget, extending the timeline of the project and planning a cautious approach. Moreover, the Enerphit project can be applied at a wide range of different buildings typologies (mainly residential -single and multi-family- and commercial buildings) with no specific restrictions and appear to be particularly favourable in the southern area of EU, as the number of already completed renovation project in the area implementing the Enerphit model can attest.

In this context, the Spanish demonstration building of the EuroPhit project[10] has been selected as Business Case. This is a **large residential building (multi-family)**, located in Madrid, **Spain**, with 14 floors and 72 apartments built in 1963. The renovation of the building was undertaken starting from the EuroPHit project with a Step-by-step approach. The first step was undertaken by owners of a single apartment, who decided to improve their dwelling, including exterior wall inner insulation (just to ensure hygiene and comfort inner conditions), high-quality windows installation and connections with walls, airtightness improvement and ventilation system with heat recovery. The two next steps of the refurbishment plan affected the entire building (ETICS installation, roof insulation and basement ceiling insulation).

PACE financing is a relatively new concept: the first pilot programme was undertaken in 2008 in the city of Berkeley. It is attractive as it provides access to capital for property owners to invest in RET and EE measures, thus overcoming the barrier of high-up front costs. In addition, it incentivises long-term investments because the repayments of the special tax assessment may be done over 15 to 20 years and the lien on the property stays with the property when it is sold. The main prerequisite to enable PACE financing or a similar programme is a change in legislation that enables the creation of special tax assessment districts or similar arrangements, and the acceptance of all stakeholders The EUROPACE running project, having installed a pilot in Olot, Spain, is one of the most promising solution for the geographic area, presenting a good level of replicability if public authorities will decide to support such model. However it was not possible to select EUROPACE pilots as BC since results were not yet available at the moment of publication of the present document.

Within the Southern Area, further business cases have been identified, perfectly fitting with the building typology more widespread, namely residential buildings (apartments and single-family houses), while the

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[9] https://smartcities-infosystem.eu/sites-projects/projects/e2rebuild - Industrialised Energy Efficient Retrofitting of Resident Buildings in Cold Climates

[10] https://europhit.eu/ - Retrofitting for the energy revolution, one step at a time

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related Business Models evaluated were the EPC, Energiesprong and Step-by-Step Approach. In particular, in addition to the Spanish one, the following business cases have been identified in the Southern Area:

- **Social Housing Apartments**, located in the North of **Greece** and built in an area of approximately 20 acres. Within this area 26 buildings built in two phases (in the 1970s and in the 1980s) were selected to be renovated within the ECOLISH[11] project, aimed to investigate the possibilities for energy efficient retrofitting for low incomes and social housing by using EPC model. These buildings were characterized by insufficient insulation and poorly managed heating systems.
- **Multi property residential buildings**, located in the Torrelago district, in Laguna de Duero, **Spain**. The renovation was implemented in the framework of the FP7 funded CITyFiED[12] project and involved 31 private multi-property residential buildings (1488 dwellings) that were constructed in the 1970s – 1980s, more than 140,000 m^2 and 4000 residents involved. Former conditions of the district were very low in terms of efficiency, comfort and costs, which fostered the intervention.

2.2.3. *Western area*

The most promising Business Models selected for the Westen area were Energiesprong and Remourban.

The Energiesprong approach providing zero energy homes at zero upfront costs in The Netherlands – proposes a new financing and construction model. Its success is based on the idea to move from a product-centred approach to an industrialised, service-oriented approach that uses innovative technologies, business models and/or finance models (such as selling products and services within an integrated framework), ultimately reducing the cost of energy renovations. Yet this industrialisation process that brings down the costs of the refurbishment is enabled by proper segmentation of the building stock. Much of the success of the programme is due to the identification of a very specific segment of target buildings (residential multi-family buildings) allowing a replicable approach to each of the projects. This suggest a huge potential for the business model in the geografic area of Western EU: the project started its activity in the Netherlands expanding then to United Kingdom and France, but other countries with similar climate conditions could be targeted.

The other business model selected as most promising for the Westen area is Remourban that intends to promote Energiesprong business model combining a set of EE and RET measures, together with an active involvement of Public Authorities, private owners and citizens. The Nottingham pilot project is a perfect example of the potential that the business model can represent, for a large scale renovation of urban areas guided by a centralized public authority, coordinating and promoting renovation measures. The model appears to be particularly suitable for the Westen area also thanks to a geo-political similar context and similar market conditions.

In this framework, the main business case identified was from France, consisting in **typical brick individual houses**, located in Hern, **France**. built in 1952 with a very low energy performance. These buidlings

[11] https://issuu.com/ecolish/docs/ecolish_flyer_website - Energy Exploitation and Performance Contracting for Low Income and Social Housing

[12] http://www.cityfied.eu/ - RepliCable and Innovative Future Efficient Districts and cities

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constituted the first test of the EnergieSprong approach in France within the E=0[13] project, funded by Interreg North-West Europe, to demonstrate the replicability of the project.

In addition to that, business cases identified in the Western Europe area fitted the more widespread building typology, namely residential buildings, including both single family houses and multi-family buildings, while the related Business Models evaluated were the One Stop Shop based on Private-Public Partnership and the Add-On Business model. In particular, the following business cases have been identified in the Western Area:

- **Single family houses and terraced houses,** located in Kroeven Roosendaal, **Netherlands**, were part of a larger regeneration project for the whole area, which includes demolition and new construction at strategic places, but focuses on major energy renovation of terraced houses built in the 1960s. Prefabrication of façade and roof elements have been used as the main means of renovation, with the aim of reducing the disturbance of tenants, constant and high quality and good energy performance.
- **Social housing apartments and district single family houses,** located in Sneinton district, Nottingham, **UK**. The renovation is being implemented in the framework of the Horizon 2020 project REMOURBAN[14]. The project is focusing on a variety of property ranging from single-family to multi-family houses, and in age, from 1900 to the 70s. A large number of the properties (65%) in the area are social housing, owned by Nottingham City Council (public owner) but renovation is extended to other buildings in the district from private owners.
- **Residential multi-storey buildings,** located in the suburb of Sendling, Munich (**Germany**) consisted of two blocks built in 1954. The buildings, owned by the public housing company GWG München, represented uniform standard concrete brick blocks built in the post-war decade of the 1950s. The renovation of the buildings, performed in the framework of the E2Rebuild project, was completed in a year have, including the replacement of the attic by an additional floor to create more rental space, increasing the Net Dwelling Area.
- **Multi-family building,** located in Delft, **The Netherland**, namely the Complex 5, is constituted by 108 dwellings distributed over 3 types in 8 blocks constructed in 1958. Within the BEEM-UP project, a Public Private Partnership collaborative project aimed at demonstrating the economic, social and technical feasibility of retrofitting initiatives, the complete refurbishment of the building was performed.
- **Multi-family building,** located in the centre of Paris, **France**, is constituted by 87 apartments built in the 1950s and owned by ICF Novedis. . In 1993, the building was renovated (outer insulation, double-glazed windows, boilers), but it needed a major upgrade to become a pilot and an example for bringing the rest of the housing park to the low energy standard for renovated buildings. Also for this business case, the renovation work was carried out as a pilot demonstration site of the BEEM-UP Project, a Public Private Partnership collaborative project.
- **Residential apartment block**, located in Graz, **Austria.** The residential area Dieselweg comprises five single buildings and one long building row. One single building – Dieselweg No.4 – was chosen here as representative for all others. It consists of 16 apartments, built in 1959 and renovated in 2008-2009 for a total floor area of 1589 m^2. The renovation was supported by the Austrian system of public housing aid, by additional research funds and by a special support of the governor of environmental affairs of Styria and by the non-profit organization of the GIWOG Corporation.

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[13] http://www.nweurope.eu/projects/project-search/e-0-desirable-warm-affordable-homes-for-life/ - Desirabe, warm affordable gomes for life

[14] http://www.remourban.eu/ - REgeneration MOdel for accelerating the smart URBAN transformation

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2.2.4. *Eastern area*

The most promising Business models selected for the Eastern area are EPC plus and Enerphit. EPC plus aims at eliminating barriers for implementation of EE measures and RET through standardisation of technical interventions and simplified financing. The implementation of the measures always follows a dedicated standardised process, making it scalable and replicable at large scale. Enerphit already showed its applicability in countries of the eastern area of EU, particularly in Bulgaria. The possibility of the model to be applied to different categories of buildings and to be flexible, both in the solutions to implement and in the timeline of implementation, suggest its selection as most promising in the area.

Within the Eastern Area, one business case has been identified, related to a non-residential educational building, implementing a the Enerphit BM (Step-by-Step approach). This is a **primary school building**, located in Gabrovo, **Bulgaria**, built in 1970. It has a concrete structure with external brick walls and concrete flat double ventilated roof. Since 2013, the school has been connected to the central gas heating. The renovation of the building was undertaken during the EuroPHit project.

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3. Business Cases' analysis

After the selection of the most promising BMs, 14 Business Cases where these BMs have been applied with success for the refurbishment of low energy efficiency building stock have been identified. As the users in the Renovation Hub may select the Business Model that most fit its requirements according to building types and geographical location, same filters have been used for the BC analysis. In addition to that, the analysis of the application of the related BM has been done to provide recommendations and insights useful for the Renovation Hub users. Such analysis aims at i) providing the most interesting features for the implementation and achievement of business targets, ii) searching for distinctive elements as well as common features of the promising BMs and iii) understanding the lesson learnt from the application at BC. To this aim, the analysis has been performed at three different levels:

- At **geographical level**, to evaluate the external boundary conditions influencing the BM application as well as the geographical coverage of the BC identified to prepare the ground for replication
- At **building level**, to identify the internal boundary conditions, namely the building features as well as the typology of building ownership.
- At **Business Model level**, to analyze in details the application of the identified BM to the real case study and evidence each aspect (from the channels used from the technology providers to the market, as well as actions due, how they should be executed and who should be involved, etc.)

3.1. Analysis at geographical level

As mentioned above the analysis of the gathered BC at geographical level aims at evaluating first of all the geographical coverage of all the climate conditions in EU to ensure the widest replicability as possible. Then, the analysis shall provide an overview of the so called “external boundary conditions” influencing the deep renovation success. In this context, when evaluating the potential replicability not only of a particular RP but also of a BM the influence of local constraints, regulations and incentives shall be taken into account.

As can be seen in figure below, the geographical coverage has been guaranteed providing at least 3 or 4 Business Cases per climate area. The only exception is represented by Eastern Area where it was difficult to find real cases of deep renovation according to the most promising BM evaluated within the project. In this case, more accuracy in D5.3 “Report on replicability potential” will be dedicated for the evaluation of replication potential in this geographical area. Most of the business cases are represented by social housing buildings, thus confirming the very low energy performances of this building stock.

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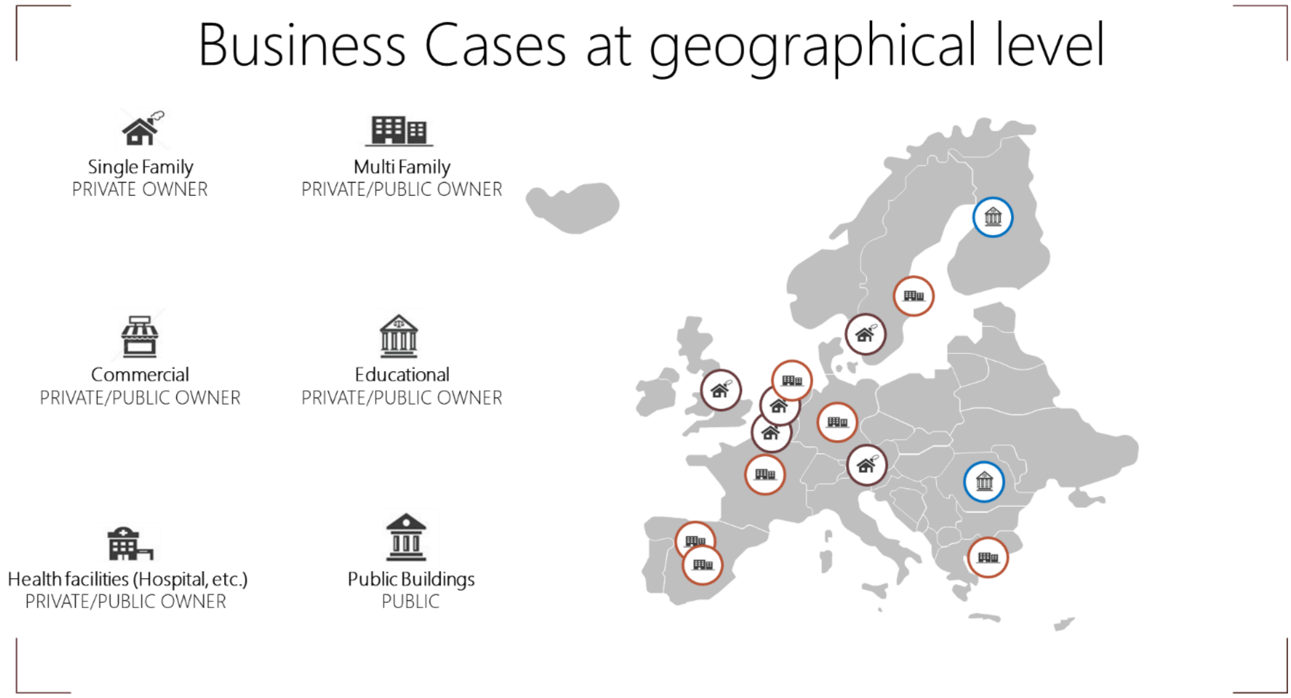

Figure 3.2: Business Cases at Geographical level

Concerning the external boundary conditions influencing BC deep renovation, a screening analysis of the main local constraints, regulations and incentives influencing the BC deep renovation is provided in figure below.

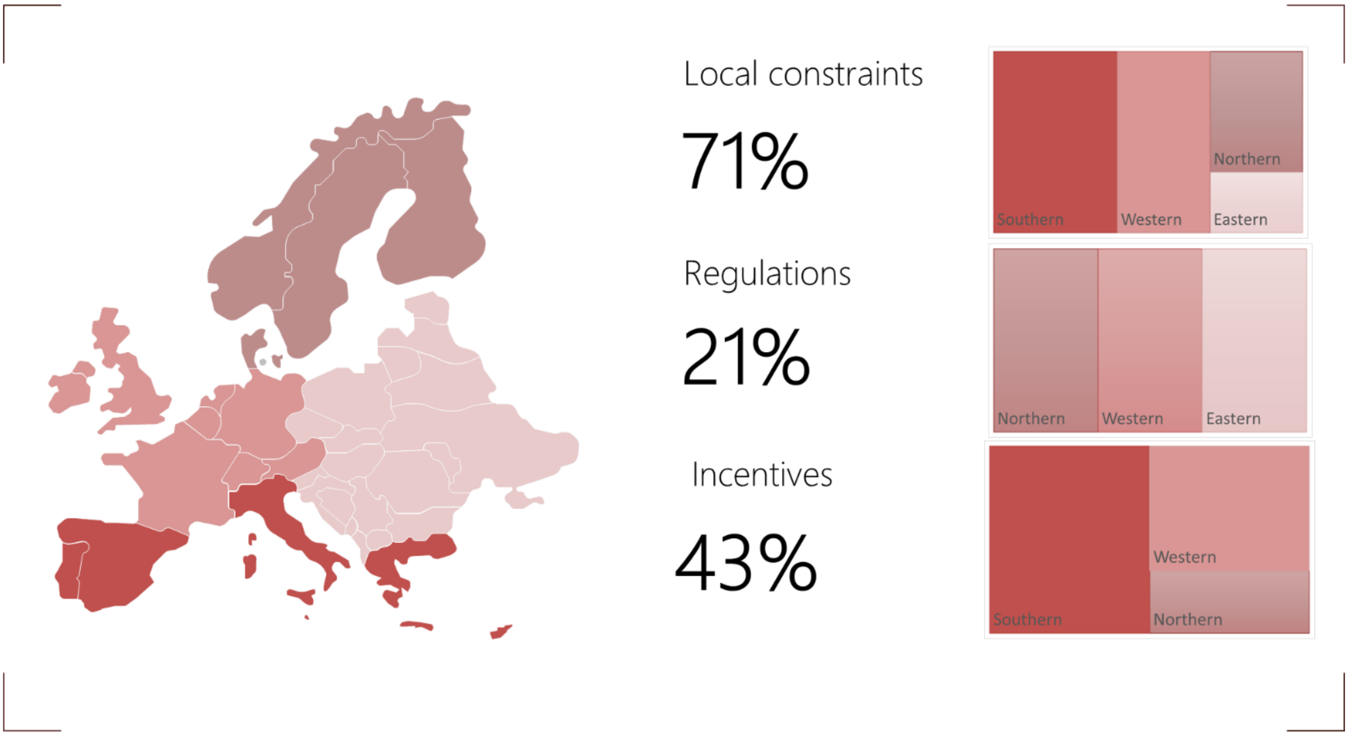

Figure 3.1: External boundary conditions influencing BC deep retrofitting

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Concerning local constraints, more than 70% of the BC provided mainly constraints related to:

- **Building materials** to be used (as the building was under heritage building conservation and thus original appearance and specific requirements shall be verified);
- **Decision making process in private multi owner buildings as most of the times it was difficult to reach an agreement**. Indeed, for example Spanish regulation requires that the renovation has to be approved by a minimum of 60% of the owners. In addition to that, most of social houses in Spain are not rented but owned. The fact each condominium has a different owner makes it difficult to perform community retrofits in common areas because every change or intervention has to be ratified by the majority of these.
- Most of the time the **deep renovation intervention required empty buildings** and the tenants had to translocate at an early stage in the project and this was something to be foreseen and managed on time. In some cases, as the owner of the building was a big social housing company it was possible to translocate people to other dwelling houses in the near sourrounding, in other cases, retrofitting interventions needed to be designed in such a way that buildings occupants remained inside.
- **Health and safety constraints**, as in the case of Swedish business case, where radon constitutes a relevant constraints when retrofitting an old house. Radon gas can enter buildings from the ground, building materials or household water and the Swedish Radiation Safety Authority estimates that radon in dwellings causes around 500 cases of lung cancer per year in Sweden. Measurement is the only way to detect radon levels. In many places in Sweden, radon gas is an issue, which needs to be addressed carefully when renovating existing buildings.

Concerning regulations, the main constraints deriving from regulation issues were related to the **energy performance target** to be achieved after retrofitting intervention. Indeed, in some business cases (e.g. Finland), the building retrofitting works took place before new statutory regulations were implemented. In those cases, regulations for new building were applied to the project due to the extent of the retrofit, and the building permit application to local building inspectors was evaluated according to existing new building regulations. To a large degree current Finnish building regulations do not anticipate the real risks of deep retrofits and requirements for new built are not directly applicable. Regulations for new building focus on fire risks, concrete structural requirements and safety. The Finnish business case (the Oulu student apartment) showed that in retrofit practice there were other priorities for inspection of building works than for new building. There was a need for inspection of construction tolerances in prefabricated elements, verification of airtightness improvements, precautions for differential structural movements in foundations and ground slabs under improved thermal conditions, and the moisture protection and quality control of timber structures.
Instead, a drawback in the Dutch market was the **scale of the national energy-labelling scheme**. In the Netherlands much less energy efficient schemes than demonstrated are entitled to be A or B-rated. Real energy efficient renovations are not encouraged because of the chosen calculation method behind in which it is not possible to calculate and to value a passive house renovation scheme. Real energy performance figures though indicate that much better energy performance levels than referred to in the Dutch A and B rating are needed to achieve affordable heating bills and desired CO_2 emission levels.
Finally, a constraint in the Bulgarian Business Case, was related to the target limits required by the Bulgarian National Standard. It describes maximum value of the heat transfer coefficient on elements in building envelope (e.g. for walls (U=0,35 W/m^{2}K), roof (U=0,28 W/m^{2}K), floor (U=0,45 W/m^{2}K) and door and windows (U=1,7 W/m^{2}K)) but it does not limit the maximum value of the energy use.

Finally yet importantly, a relevant factor influencing the business cases deep renovations was the **incentives**. First, it has to be taken into account that most of the buildings were the “demonstrator pilot” building in EU project, thus taking advantages of EU financing. Then, the EU funding was also maximized with National incentives, as in the case of the following BC:

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- BC in Stockholm, where it was exploited a tax-reduction scheme called ROT-avdrag, which is done yearly and therefore step-by-step has an additional benefit since the reduction can be applied over several years (tax-reduction up to 50 000 euros/year on work carried out at the building by professional craftsmen).
- BC in Greece, where the Pieria building was also selected as case study for an initiative called "Promoting renewable energy and energy efficiency in rural areas" that was funded under "Intelligent Energy Europe Programme – EIE/04/223/S07.38603"
- BC in UK, where to help householders pay for their contribution, NEP and Nottingham Credit Union introduced a zero interest loan.
- BC in Austria, where grants, subventions, 0 interest loan, tax rebate, etc. were available

In these BC, the deep retrofitting was a more realistic option as the cost could be spread over a number of years without accruing extra costs.

3.2. Analysis at building level

The analysis of the BC from the building point of view aims at providing an overview on the coverage of different typologies of building as well as evaluating the "internal boundary conditions" influencing renovation, namely the building typology and type of ownership, the building features and the related energy performance before retrofitting.

As represented in the following figure, the main focus was put on the residential market, representing the most representative one within EU building sector[15] (75%) and the most promising in terms of potential for renovation. The BC selected, in particular, refer to single family houses and multi-family-houses, ranging from terraced houses to multi-storey residential buildings, as reported in Table 2.1. The only non-residential building under examination related to an Education building, namely a Primary School, located in Gabrovo, Bulgaria.

Concerning the type of building owner for the selected BC, it is possible to note that the majority of them (12 in total) relate to Public building owners, in particular the database includes a number of social housing buildings. Also private owners BC are included in the analysis (3). The Nottingham BC, finally, represent a district renovation in which a large number of buildings were retrofitted, including both building owned by local social housing association (Public owner) and a number of private building owners.

In the following table a detailed categorization of renovation packages adopted during renovation works for each of the BC under analysis is reported in order to extract common features and useful insights on the renovation approach adopted.

[15] https://ec.europa.eu/energy/en/eu-buildings-database

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Table 3.1: Building typologies and refurbishment packages adopted

BC Code	Business Case	Project	Building Type	Type of building owner	Refurbishment packages								
					Envelope	Floor	Roof	Windows	HVAC	RET	Lighting	EMS	Other
N1	Alingsås, Sweden	BEEM UP	RS	PU	x				x	x	x	x	x
N2	Stockholm, Sweden	EUROPHIT	RM	PR	x	x	x		x				
N3	Oulu, Finland	E2REBUILD	RM	PU	x			x	x		x		x
S4	Torrelago, Spain	CityFIED	RM	PR	x							x	
S5	Pieiria, Greece	ECOLISH	RM	PU	x			x	x	x			x
S6	Madrid, Spain	EUROPHIT	RM	PU	x		x	x	x				
W7	Hem, France	E=0	RS	PU	x		x		x	x		x	
W8	Delft, Netherland	BEEM UP	RM	PU	x			x	x	x	x	x	
W9	Paris, France	BEEM UP	RM	PU	x			x	x	x	x	x	x
W10	Munich, Germany	E2REBUILD	RM	PU	x		x		x	x			x
W11	Roosendaal, Netherland	E2REBUILD	RS	PU	x	x			x	x			x
W12	Nottingham, UK	Remourban	RM	PU & PR	x					x		x	x
W13	Graz	SQUARE	RM	PU	x				x	x		x	x
W14	Gabrovo	EUROPHIT	NE	PU	x	x	x	x	x	x			x

<u>**Legend:**</u> **Building Type:** S – Single Family, M – Multi-family, E – Educational; R – Residential; N – Non Residential
Type of building owner: PU – Public, PR - Private

From the table provided in the previous page it is possible to desume a number of key aspects related to the most adopted renovation measures.

- **Building envelope (100%):** The building envelope is the interface between the interior of the building and the outdoor environment, including the walls, roof, and foundation. By acting as a thermal barrier, the building envelope plays an important role in regulating internal temperatures and helps to determine the amount of energy required to maintain thermal comfort. Minimizing heat transfer through the building envelope is crucial for reducing the need for space heating and cooling[16].
  All the BC under consideration include the renovation of external envelope as one of the main renovation measures undertaken.The technical solutions range from more traditional solutions, as the adoption of mineral wool or hollow concrete blocks, to prefabricated solutions, such as ventilated facades, aiming at insulating external walls and provide ventilation at the same time.
- **Heating, Ventilation and Air Conditioning – HVAC (86%) solutions:** The HVAC system is the main responsible for regulating the climate of a building and maintain the comfort and safety for the occupants. The majority of BC under analysis adopted solution related to HVAC.
- **Renewable Energy Technologies – RET (61%)** renewable energy technologies implemented in the BC under analysis can be traced back to the technologies of photovoltaic solar panels and solar thermal technologies. These systems provide useful energy, both in the form of electric energy and/or heat, resulting in a valuable reduction of energy consumption for the building.
- **Energy Management Systems – EMS (50%)** were installed by half of the BC under analysis. The correct energy monitoring and management can play a crucial role in regulating internal parameters (temperature, humidity, quality of air) and provide comfort for tenats.

Also other measures (e.g. smart meters, etc.) can provide significant results, in fact it is essential to remind that a comprehensive renovation plan, including case-specific measures represent in any case the essentiasl starting point for each renovation intervention.

Finally, as provided in figures below, also other parameters were considered when evaluating the selected business cases, namely ages of construction, floor area, energy performance before and after retrofitting as well as the investment cost when possible.

As can be seen, half of the BCs were built in late 1950s, when the interest in energy efficiency was very low.

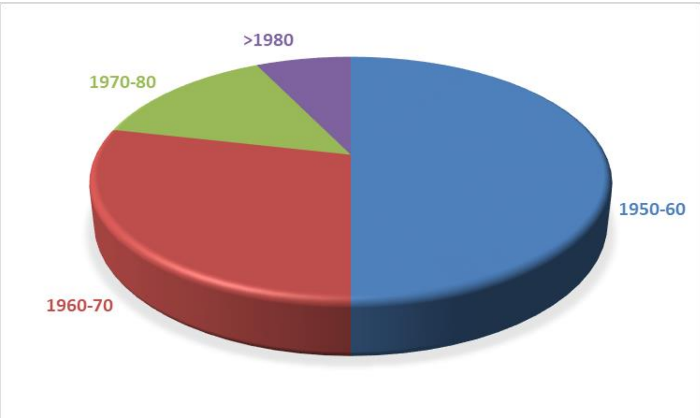

Figure 3.3: BCs age of construction

[16] „D2.1 - Report on retroffitting of building envelope", RepliCable and InnovaTive Future Efficient Districts and cities, – GRANT AGREEMENT No. 609129

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Looking at the energy savings, almost 10 pilots had more than 55% of energy savings after retrofitting. Exceptions were due to the fact that only a first step in building deep retrofitting has been performed (as in the case of S6) or less floor area (BC N2). Highest energy savings have been achieved for the biggest BC in terms of gross floor area (W13, N1).

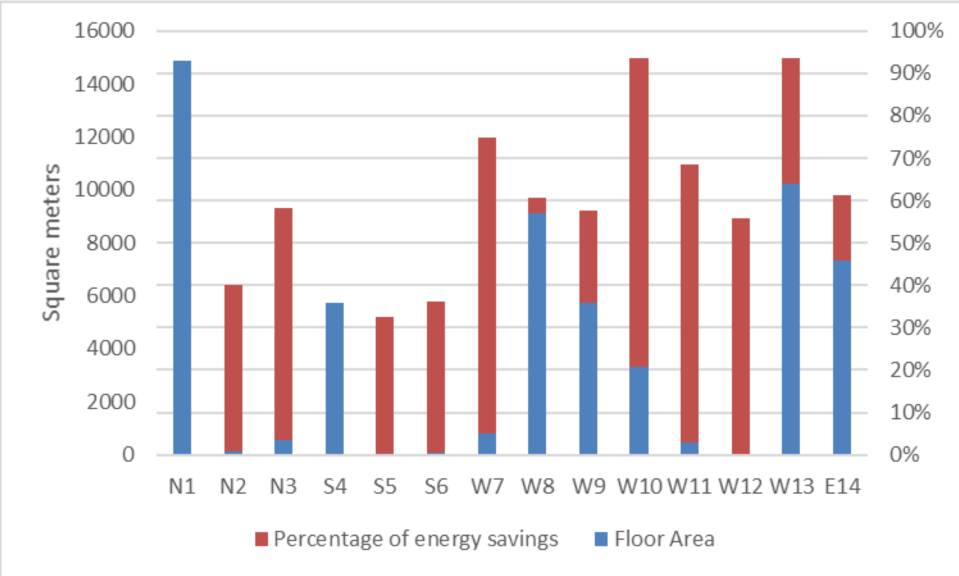

Figure 3.4: Energy savings vs Floor Area

Average total investment cost was about 4 million Euros. The biggest BC provided the highest investment cost as well. Total investment cost comprised also potential financing from EU, or local government or other entities that thus can mislead the interpretation of the overall cost per square meter. The average cost per square meter has been estimated to 780€/m^2 that takes also into account the innovations proposed within the EU related projects.

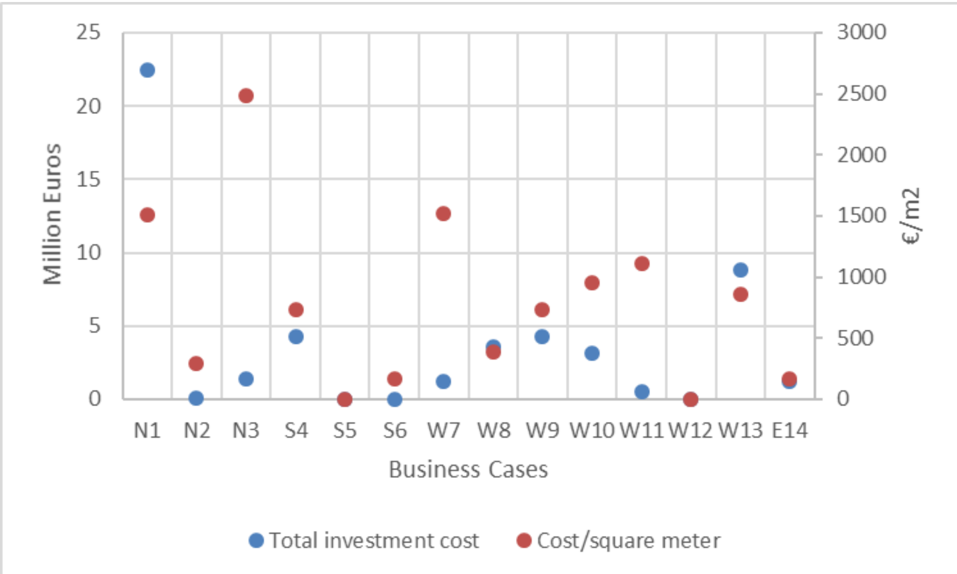

Figure 3.5: Total investment cost vs cost/square meter

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3.3. Analysis at BM level

Analysis of Business Cases identified based on the Business Model that has been applied is provided hereby. The analysis aims at highlighting the following aspects:

- A detailed evaluation of **how, when and why** the Business Model has been applied as well as **who** is the target client and **what** is the real added value achieved in the real business cases application. This allows evaluating the Business Model (described in D5.1:"Report on the scenario identified") under a different perspective, the perspective of BC reality, thus taking into account potential problems, bottlenecks, etc. The overall scope of this analysis is to evaluate compliancy with the BM and if not to highlight potential lesson learned from it. When available key features that had a relevant role on the BM success have been highlighted as well.
- Evaluation of **common factors** of each BCs (in case of more than 1 BC it may be relevant to evaluate common procedures or synergies) as well as general **lesson learned** desumed by the specific BC.

Thus, the first analysis focuses on the BC itself against BM theoretical application, while the second one aims to find out general recommendations from the specific BC application towards general widespread of related BM.

3.3.1. One-Stop-Shop provided by Public-Private-Partnership

The Public Private Partnerships (PPP) is a well-accepted delivery model in the construction sector, involving a contract between a public sector authority, the public building owner, and a private contractor in charge of the management and the development of the building renovation project. The private party provides the service to the public authority, assuming substantial financial, technical and operational risks in the renovation project.

In this collaborative model, private and public partners collaborate coordinating their skills and knowledge for long-term contracts (usually 20-30 years). The selected contractor involves designers, maintenance services providers and other subcontractors needed stipulating specific contracts with each of them, during the whole project duration, being the only contact point for the public building owner.

PPP models are mostly used in very complex projects that require high level of integration. Since PPP delivery method is widely used around the world, many types of financing contracts may be used under this scheme: usually, for instance, the contractor finances the initial investment and the client pays a constant fee for using the property during the contract. In some cases, a private sector consortium may create a special company called a "Special Purpose Vehicle" (SPV) to develop, build, maintain and operate the asset for the contracted period.

PPP model are usually implemented in the case of multidisciplinary projects where team members have to strongly collaborate. Because of the mix of responsibilities and finance schemes, PPP delivery models provide opportunities for both public and private sector. However, PPP are complicated delivery models that require strong involvement of the different stakeholders, therefore PPP delivery method may cause an increase in time and cost of projects delivery and increase potential risks associated to the different steps of development.

1.1.1.1. Business Model applied at Business Cases

Among the Business Cases identified, this Business Model has been applied in three different BCs, one in Northern Europe (Sweden) and two in Western Europe (The Netherland and France). Applications are thereby provided, detailing what has been done, by whom and how.

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Multi-dwellings residential building in Brogården in Alingsås, Sweden

Images (PRE/POST)		
Energy performance (PRE/POST)	The energy consumption was 177 kWh/m^2, where the heating related consumption was 115 kWh/m^2, the hot water 42 kWh/m^2 and the electricity of the building was 20 kWh/m^2.	The energy consumption after retrofitting is 48 kWh/m^2 in total, where only 19 kWh/m^2 belongs to the heating system while the hot water system reduces its consumption to 18 kWh/m^2 due to the new solar collectors. Finally the electricity of the building is 11 kWh/m^2.
Business Case: N1	**Comparison to BM**	**Note on compliancy with BM towards achievement of target**
WHO	This BC is about eight 2-4 storeys multi-family buildings grouped around courts, built between 1971 and 1973 and counting on 144 apartments and 14860 m^2 living area in total, with balconies and patios. It belongs to AB Alingsåshem which is a municipal housing corporation in the municipality of Alingsås. Union of Tenants has a key role in communications with tenants.	Public building owners planning complex renovation projects that require high level of integration. Tenants were evacuated.
WHAT	The following added values have been provided: • The public owner (AB Alingsåshem) identifying the need of a refurbishment of a public building contracts with a private contractor (SKANSKA), in charge of the whole complex renovation project • Simple structure with only two prime players: public owner and contractor • The contractor had full responsibility for the design, construction, financing and final result achieved, assuming the relative risks • The private contractor takes responsibility for functions such as operating and maintaining the building, with a long-term contract	Almost complete value proposition satisfied
HOW	The public owner had a single reference contact with the private contractor that is in charge of all the aspects of the project, including the choice of sub-contractors to perform design, construction and maintenance services during the renovation project and all over the contract duration. As	Big contractor has been a relevant choice. The knowledge developed at Brogården has spread to other projects, through

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	SKANSKA is one of the world's leading project development and construction groups this was not a problem. Big reduction of energy consumption, around 60 %, has been achieved. The inclusion of high energetic efficiency equipment in lighting and water achieved a marked reduction in energy consumption in these systems.	e.g. over 700 study visits and collaborations in national and international energy efficiency programs.
WHEN	Works began in August 2011 and finished in September 2014. 9 months per building.	Timing respected
WHY	The total cost is approximately € 22.5 million where there were some grant of € 0.68 million by European Union and € 0.4 million by local government, the rest was paid by a loan. Despite achieving good results with energy savings in line with the initial goals, the project faced a serious regulatory barrier and, as a consequence, the return on investment could not be realised. Indeed, according to the Swedish legislation, it is not legal to raise rent due to energy efficiency measures, i.e. the costs for a passive house renovation cannot be recovered by a rent increase. It is, however, fully legal to raise the rent due to 'improvements to the living standard in the apartment'. This was the crucial point to overcome the legal obstacle. Indeed to improve living standard, project partners came up with creative solutions (see "key features" below) that allow the achievement of the target ROI.	Relevant bottleneck resolved

Key features:

The project has been in total very successful and this was likely thanks to the deep involvement and the partnership model of the project. Every project member did contribute, share their experiences and ideas and help each other at a much deeper level than in normal retrofitting projects, because of the shared objective and incentives, the deep dialogue and the team spirit of the project. Thus, an overview of the key features that made the difference in the successful implementation of the deep retrofitting are provided below:

- **Administrative financial aspects**

  Project partners came up with a number of creative solutions to overcome the legal obstacle hidering the ROI achievement and to demonstrate the improved living standard. These solutions indeed allow to raise the rent due to 'improvements to the living standard in the apartment': i) Indeed, before the renovation, heating was an important expense item. Due to the passive house technique, the cost for heating became minimal, resulting in radically decreased future expenses. ii) Before the renovation, the household electricity and hot water were included in the rent. After the renovation, these costs were transferred to the tenants (as specified lines on the rent invoice). To charge for the household electricity is normal Swedish procedure and before the renovation the Brogården housing estate was an exception. To charge for the hot water is a new Swedish standard. Owners do not earn any money by charging for water or electricity, however, they are relieved of a significant cost. iii) In order to address a significant thermal bridge, the original indented balconies were moved out in line with the façade. This meant that all apartments gained space of 4 m^2. Owners could charge extra rent for the increased space. Owners were also able to create fully accessible bathrooms in all flats and could charge extra rent for accessibility. Furthermore, the deep renovation meant that all flats have new build standard – and thus they could charge extra rent for 'improvements to the living standard in the apartment'. The fact that the apartments got significantly better indoor climate after the renovation can also be considered as 'improvements to the living standard', which makes it eligible for a rent increase.

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- **Social interaction** was an important part of the deep energy refurbishment. Indeed, the tenants had to relocate during the project; however Alingsåshem offered them apartments in the same area while the renovation was being carried out. For Alingsåshem it was especially crucial to make sure that everybody was “on board” for this massive change. Therefore, Alingsåshem relied on the household lifestyle profiles in order to find out what different groups of tenants really want in relation to their homes. At the first stages of the refurbishment the tenants were only involved indirectly through their household lifestyle profiles and their service notifications. As a result Alingsåshem obtained information on how important different issues are to different tenants groups. In the next stage Alingsåshem established a continuous dialogue with tenants all through the process by setting up open house meetings and by creating a newsletter. Within the whole process of refurbishment tenants have had the opportunity to react to the progress in all stages of the project. Their feedback might not influence how the actual house is built but it has given Alingsåshem opportunities to adjust the shared spaces and some details in response to their comments. The tenants were often invited to a discussion. The Swedish Union of Tenants contributed to a workshop where the tenants were involved to come up with ideas for how the defects could be redressed. All the “first tenants” in the flats have had the opportunity to choose wallpapers and kitchen fittings. These are details in such a sizeable project, but it’s an important aspect for the tenants. Usually they make their choices when signing the contract – which is normally at least three months before they move in. After renovation, some tenants (approximately 25 %) did not get back due to the large rent increase (an average of 40 %) but in general, residents were satisfied with the apartments after the upgrade.
- **Technical aspect**
  Due to cold and wet weather during the winter season, it was important to protect (if possible) the work in the external part of the building like the façade, that has been covered with a cape after the old brick facade and original balconies were removed.

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Multi-family building in Van der Lelijstraat in Delft, the Netherland

Images (PRE/POST)		
Energy performance (PRE/POST)	The energy consumption was 191 kWh/m^2/yr, where the heating related consumption was 137 kWh/m^2/yr, the hot water 21.5 kWh/m^2 /yr and the electricity of the building was 32.4 kWh/m^2/yr.	The energy consumption after retrofitting is 75 kWh/m^2/yr in total, where 75 kWh/m^2/yr belongs to the heating system. The domestic hot water increased its value from 21.5 to 33 kWh/m^2/yr although a reduction had been expected. From the data provided by the project, it can be observed that the simulations did not have enough data to properly model the demand, and therefore the design results before the retrofitting are on the whole higher than that monitored. Finally the electricity of the building is 30.2 kWh/m^2/yr.
Business Case: W8	**Comparison to BM**	**Note on compliancy with BM towards achievement of target**
WHO	This BC is about 108 dwellings (28 row houses and 80 flats with small backside gardens) distributed over 3 types in 8 blocks (7326+2355 m^2 gross living area), built in 1958. It belongs to Woonbron that is one of the largest social housing groups in the Netherlands, serving about 50,000 households and offering, in a coproducing role, housing and choices to a broad customer group in a healthy urban area that has different, but attractive, living styles.	Public building owners planning complex renovation projects that require high level of integration. Tenants were not evacuated.
WHAT	The following added values have been provided: • The public owner (Woonbron) identifying the need of a refurbishment of a public building contracts with a private contractor (DURA VERMEER), in charge of the whole complex renovation project • Simple structure with only two prime players: public owner and contractor • The contractor had full responsibility for the design, construction, financing and final result achieved, assuming the relative risks • The private contractor takes responsibility for functions such as operating and maintaining the building, with a	Almost complete value proposition satisfied.

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	long-term contract	
HOW	The public owner had a single reference contact with the private contractor that is in charge of all the aspects of the project, including the choice of sub-contractors to perform design, construction and maintenance services during the renovation project and all over the contract duration. Dura Vermeer is active in construction, infrastructure, engineering and services, developing at own risk, realising and operating projects commissioned by third parties. Dura Vermeer stands out and has an innovative method of working, offering industry-leading, integrated and sustainable solutions for a wide range of building projects.	Big contractor has been a relevant choice. The housekeeper and the tenant managers have an everyday relationship with the tenants that were not evacuated.
WHEN	Works began in June 2011 and finished in May 2013. Woonbron promised the tenants that they would have new windows when the winter of 2011 started.	Time constraints with regards to the promise to have new windows before the end of 2011 had great impact on the execution.
WHY	The investment cost for the intervention has been 388 €/m² making a total cost of EUR 3.54 million, for about 32800 €/flat. According to the data provided, the annual cost savings for energy are 77259 € on a total cost of 103012 €. Therefore, the annual costs after renovation are equal to 25753 €. The resulting payback period is more than 30 years. The financial analysis shows that a profitability of the project is not given due to the high investments in comparison to the low energy cost savings. This however does not reflect the non-monetary benefits that might occur through the implementation. Overall, the project achieved substantial improvements. The energy consumption is 15 % lower for gas (heating, hot water and cooking) than the average Dutch household and even 30 % lower than the average electricity consumption. Also comfort conditions have been apparently reached thanks to the refurbishment according to the tenants' positive comments, which were collected during interviews with them. Moreover, technical (disagreement on solar boiler technology installation) and legal (need to achieve agreement of at least 70% of tenants about retrofitting intervention) bottlenecks have been encountered but successfully solved (more details in "key features" below).	Missed achievement of profitability has been balanced by non-monetary benefits; several bottlenecks (legal and technical) successfully resolved. The improvement of the insulation value of the envelope was quite modest and did not change the heating habits. For the envelope to have an effect, a much higher thermal resistance and sealing was needed with side effects, such as the need for balanced flow ventilation. Dwellings with sober installations before the renovation did not save much energy with modern installations that provide much more comfort.

Key features:
The project encountered a technical problem with multiple families living in the same building. Only 40 % of the tenants were interested in the solar boiler technology that the project sought to implement. The reason for this was that numerous tenants had already fitted their own individual private heating installations. In order to overcome the low interest in the product among tenants and to avoid the implementation of two different energy sources for different tenants in the same building, the existing private installations were bought by the project and improved. Following this, these tenants rented the system for the same price that was offered to the others. This method guaranteed that all tenants were treated in the same way and were able to still own their own system. Thus, these dwellings have had similar improvements in their envelope.

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Some 50 dwellings have received a new installation with a solar boiler. Some 34 dwellings received a feedback system which gives occupants a real time insight into their electricity and gas consumption, as well as weekly and monthly statistics.
In addition to that, there has been also a barrier related to regulatory and administrative issues. Indeed, Dutch tenant protection regulation demands that 70 % of the tenants must agree to a physical improvement of the houses in case the property owner wants to increase the rent, thus reclaiming the costs of the improvement. This can result in the tenants disagreeing with the necessary refurbishments and blocking the project. This was avoided as the envelope refurbishments and other improvements were implemented without adding extra costs to the rent.

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Multi-family building in Cotentin Falguière in Paris, France

Images (PRE/POST)		
Energy performance (PRE/POST)	The energy consumption was 351 kWh/m^2/yr, where the heating related consumption was the highest contribution with 263.8 kWh/m^2/yr.	The energy consumption after retrofitting is 149 kWh/m^2/yr in total The interventions for the retrofit reduced the space heating demand to below 73 kWh/m²/yr, and the electricity needs were cut by more than half, from 100 kWh/m²/yr to 47 kWh/m²/yr.
Business Case: W7	**Comparison to BM**	**Note on compliancy with BM towards achievement of target**
WHO	This BC, composed of 87 dwellings and constructed in the late 50's, is located in the central area of Paris close to the Montparnasse railway station. It belongs to ICF Habitat Novedis that is a subsidiary of ICF Habitat, one of the major housing companies in France belonging to the French railway company SNCF. ICF Habitat Novedis invests, builds and maintains a 12000 dwelling portfolio mainly intermediate, first and foremost dedicated to the French national railway company's workers and to every person whose income exceeds the income threshold of social housing recipients. Committed in an approach of value creation addressed to her customers, the society leads in the major French metropolitan areas a policy of development and active renovation of its portfolio. The building has undergone a light refurbishment in 1993 (outer insulation, double glazed windows, boilers), but it needed a major upgrade in order to make it fit with the standards expected by ICF Habitat Novedis tenants.	Public building owners planning complex renovation projects that require high level of integration. Buildings were not evacuated. ICF Novedis has no active involvement in community development. Each building has a housekeeper who is available for assistance to other tenants, but this role is limited and does not include suggestions for the use of appliances or energy saving options. Nevertheless, Novedis adopted a sustainability policy in which a more active role for the housekeeper in terms of communication can fit.
WHAT	The following added values have been provided: • The public owner (ICF Habitat Novedis) identifying the need of a refurbishment of a public building contracts with a private contractor (BREZILLON, big player in the construction field), in charge of the whole complex renovation project • Simple structure with only two prime players: public	Almost complete value proposition satisfied

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	owner and contractor • The contractor had full responsibility for the design, construction, financing and final result achieved, assuming the relative risks • The private contractor takes responsibility for functions such as operating and maintaining the building, with a long-term contract	
HOW	The main stakeholders involved where: • PO: Project Owner (ICF Habitat Holding, Subsidiaries (social housing: ESH, free housing: NOVÉDIS), Managing Agency) • PC: Prime Contractor (Architect, Technical/Thermal Office) • Control (Control Office, Safety and Health Protection Coordinator, Asbestos and Lead Controllers) • Construction Company BREZILLON • Tenants The public owner had a single reference contact with the private contractor that is in charge of all the aspects of the project, including the choice of sub-contractors to perform design, construction and maintenance services during the renovation project and all over the contract duration.	Big contractor has been a relevant choice, the house keeper was used as a communication channel; one person from the construction company was dedicated to tenants interaction
WHEN	Works began in April 2013 and finished in March 2014. Duration of 19 months (including design).	Delay of 7 months due to lack in program definition.
WHY	The investment cost for the intervention was 738 €/m², making a total of 4251000 € excluding VAT (about 2 million for energy measures), about 52480 €/flat. The financial return for the project was more than 30 years. This is relatively long, but as a demonstration for a non-mature innovation under testing it could in fact be considered as short and could improve. The rental value after refurbishment would also positively affect the return on investment.	Too long ROI

Key features:

From a technical point of view, ICF decided to use on the balconies an innovative insulation material developed by BASF - aerogel boards. The material has a very good insulation performance and it is much thinner than EPS. Thanks to its properties ICF was able to save extra room on the balconies, which have very limited space. The solution substantially raised the quality of dwellings, keeping balconies accessible for tenants.

Organisation-wise and leadership appeared to be very important in a project like this where a new process model, that no one was used to, was initiated. The project would have gone faster with one project head manager handling it from the beginning to the end. As several persons also left the project during the long process, the aim and spirit of the project were lost for many newcomers who just followed a part of it. This resulted in a focus on the retrofitting work rather than in measurements, as problems rose, and difficulties to get results in energy consumption data on time. Also the multiplicity of stakeholders (inside the project consortium as well as within ICF Habitat) have played a role for the information diffusion.

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1.1.1.2. Common factors and main recommendations

In all the three BCs, the following **common aspects** have been noted:

- **Energy monitoring before and after retrofitting provide discrepancies**. Discrepancies (often in the electricity consumptions (sum of domestic and common consumptions that includes lighting consumption and DHW) could be explained due to tenants' habits most of the time. Moreover, the efficiency of old building services could not be calculated exactly, only assumptions could be made (no information was available about efficiency of old components: boiler, air change rates unsure, distribution losses). In some cases the reason was also related to the fact that the operative temperature used for the calculations was a little bit lower than the average indoor temperature observed in the dwellings.
- **Economic incentives from EU, local government or loan have been exploited.**
- **A strong communication campaign, aimed to engage tenants, has been pursued.**
  For example, in Delft a feedback group was used to develop (or check) a shared opinion on the improvements needed. The tenants feedback group assured that costs and measures were in line with households´ needs. Open house sessions have been held in order for people to have the opportunity to inform themselves about the renovation plans, to hear explanations of the plans from the feedback group as well as having the possibility to ask questions. The open house events have resulted in identification of positive and active persons, who cared about the neighbourhood and wanted to be involved in activities to improve the area. An intense social program was launched after the retrofit of the roofs and walls. Elements of the social program were a questionnaire on energy behaviour and energy consumption, idea generating meetings to promote awareness and information on energy behaviour and do-it-yourself measures in the dwellings. This program was essential in promoting participation in as many free-selective energy saving measures as possible. The promotion and awareness program involved meetings, education courses, information transfer and coaching. The goal has to find out which improved level of social interaction around energy issues could be developed and maintained afterwards. The questionnaire on behaviour and energy use has part of this program.
  In Paris, ICF Novedis decided to involve tenants within the whole process of refurbishment in order to make them accept the work more easily. Observations of the Paris pilot indicated that people who were engaged in the refurbishment were more aware of environmental issues and consequently contributed to the successful accomplishment of the project. During the pre-retrofit phase several actions in this respect have been performed. Among these: employment of new person in charge of tenant interaction, individual interviews about occupation of the dwellings, assessment of housing, use of common spaces of the building and interest in the environment (72 dwellings interviewed among 87), letters to all tenants informing about forthcoming renovation plans, meetings where general information about the retrofit project is shared, etc. During the work period: a showcase apartment has been presented to tenants at the beginning of the refurbishment, the house keeper has been used as a communication channel; information website has been used to informe about the work schedule, one person from the construction company (BREZILLON) has been dedicated to tenants interaction.

The analysis of application of OSS BM based on PPP provides general recommendations/best practices for the whole process of refurbishment. The lessons-learnt have a high potential impact on optimization of investments in retrofitting. The preliminary conclusions and recommendations are listed below according tot he following categories of refurbishment process[17].

[17] http://s15723044.onlinehome-server.info/beemup/documents/BEEM_UP_Booklet_final_040913.pdf

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Stakeholders evaluation

Housing Corporations need a strategic refurbishment programme (setting objectives) and investment plan to guide decision-making at building level. To this aim it would be suggested:

- To accelerate uptake and promote best practices, there should be more regional exchange of experience in low-energy housing.
- EU/member states need central databases on energy performance certificates/benchmarking (long term investigations).

Project development and planning

Each refurbishment project should start with the holistic technical analysis of the building and involve a broad consideration of the specific site conditions (scanning opportunities). To this aim it would be relevant to:

- Establish a multidisciplinary team + (external) expertise/designers responsible for the project development. Optimization in main contractor can occur when contractors are to be chosen at lowest price. This can be a challenge to future retrofittings focusing on high performance in energy efficiency, where many more parameters need to be considered.
- Consider critical conditions/requirement/ goals related to the building (national building regulations, financial incitements, legislation, building traditions, local/cultural aspects) as well as indoor environment (moisture, health, acoustic problems, air tightness, ventilation). New technology might also take a little more time and effort to implement in design, installation and adjustments.
- Involve tenants in the development process and make sure that the building meets their needs.

Implementations

During the work execution strong focus needs to be put on testing, quality assurance and improvement identifications. To this aim it would be relevant to:

- Apply stepwise approach or use a pilot house/flat in order to test and verify the technical solutions
- Listen to people who work on the construction site. They are aware of possible improvements, thus have a high impact on the project efficiency.
- Collaborate closely with the construction company in order to have a good understanding of project´s goals, introducing quality assurance procedures.
- Involve project stakeholders to foster the partnership model of the project that is crucial for the successful implementation of the OSS BM based on PPP. Every project member shall contribute, share their experiences and ideas, and help each other at a much deeper level than in normal retrofitting projects because of the shared objective and incentives, the positive dialogue and the team spirit.
- Involve the tenants. On-going interaction makes the tenants feel “seen” and implement small adjustments if needed. Refurbishing in a situation where the tenants stay in their house requires extra attention for their wellbeing and attitudes of the workers. The continuous dialogue with the tenants and the good collaboration within the procured partnership shall be encouraged. In addition, understanding that these were not merely houses but people’s homes, where they tried to continue living their daily lives despite the renovation works, made a difference.
- Focus more on insulation to obtain better than moderate results. For example the natural ventilation can be energy efficient, considering avoiding electricity use for fans and the embedded energy of installation and maintenance, but for real low-energy dwellings heat recovery ventilation is welcomed for the few winter months. Also solar thermal system is welcome as well as part of the package and a large grid-connected PV area.

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	Documentation and monitoring
Include deployment of ICT solutions within the refurbishment towards energy monitoring. Monitoring data is of crucial importance for energy retrofitting, since quantified data shows the expected and real performance of a building after a refurbishment. Moreover, reliable data allow for spotting errors in a construction and thus help to establish suitable refurbishment plans. Monitoring also encourages tenants to save energy and water and requires low investment ICT application that is considered the best cost effective energy measure possible.	

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3.3.2. One-Stop-Shop based on Step-by-Step approach

The Step-by-Step renovation model is a wide diffused model of building refurbishment that consists in the repairs or replacement of different building components, such as the windows, plasterwork, roof covering, boiler etc. according to their life duration. One of the benefits of such an approach is that it gets the most out of each building component so that the initial investment is taken advantage of to its fullest.

The need of repairs or replacement of various components arises at different points in time. Inevitably, in the case of a complete retrofit building components that are still intact are renewed unnecessarily before time. In the step-by-step approach this can be avoided.

When applying a step-by-step approach, at least a rough overall plan should be made for all measures including those which lie in the distant future, before starting the work. In this way it can be ensured that an optimal end result is achieved in terms of cost-effectiveness, energy efficiency and quality.

The building owner, being it a private or public owner, in collaboration with the designer (planner) defines a planning for the renovation measures to be carried out and a timeline of implementation. The different contractors are involved by the owner in the renovation project in successive phases, according to the initial plan. The design risk is shared between the owner and the designer, while different contractors assume the construction risks associated to their tasks.

The following points should be included in such forward-looking overall planning:

- **Chronological order of the measures**: besides the expected time-point for the renewal of the individual components this also depends on the functional context. For instance, for window replacement with airtight windows, the installation of a mechanical ventilation system will also be necessary at the same time. Similarly, a heat pump with low temperature heating can only be installed if the heating load has already been largely reduced by means of insulation measures.
- **Energy-relevant quality of individual building components**: if the future quality of thermal protection of all building components is determined in advance, then the energy standard of the building that is achievable in the future can be ascertained by means of an energy balancing software program. The future energy costs and savings can also be determined with this. The transparent final goal provides motivation for implementing the necessary building component quality at each step.
- **Building envelope** – position of the airtight layer and insulation layer: if the approximate location of the airtight layer and insulation layer in the building component structure is specified, then it will be possible to find out whether the two layers can be continued without any gaps at the component connections as far as possible – even in the case of adjacent components which are not being modernised at the same time. This is the only way to achieve a building that is airtight and thermal bridge minimised as a whole.
- For **subsequent measures, clarify in advance the points that must be given attention now**: a good standard of thermal protection can only be achieved easily and cost-effectively if the interrelationships between measures that are not being implemented at the same time are kept in mind in advance. A typical example is that of a new balcony which is already joined to the (as yet) uninsulated wall of the house with a thermal separation. What at first does not seem to make sense in terms of construction prevents a massive thermal bridge at a later point in time when the wall insulation is carried out, and therefore makes it possible to realise the full potential for saving energy.
- **Economic efficiency analysis** (optional): if the energy savings achievable over the useful life of the measure are compared with the investment costs which are necessary for improving efficiency going beyond the level for maintenance alone, then it will be easy to recognise whether a measure is successful in economic terms as well. As a rule, this may support the building owner‘s decision to

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implement ambitious efficiency measures. In addition, the building owner can already plan for the necessary investment funds in the long term.

In conclusion, step-by-step modernization permits to building owners with limited financial resources to spread the investment costs for modernisation measures over a longer period of time. Moreover, the model permits to avoid unnecessary renewal or repair of components that are still good in terms of appearance and function. The extra costs for improving the level of thermal protection will often be moderate if energy saving measures are carried out at the same time as repair work that is necessary in any case. This speaks in favour of energy-related modernisation of each building component only when it needs to be repaired anyway.

1.1.1.3. Business Model applied at Business Cases

Among the Business Cases identified, this Business Model has been applied in three different BCs, one in Northern Europe, one in Southern Europe and one in Eastern Europe. Each of the BC is representative of a different Building typology, namely a single-familiy house, a multi-family house and an educational building. Applications are thereby provided, detailing what has been done, by whom and how.

Typical detached villa, Stockholm, Sweden

<table>
<tr><td>Images (PRE/POST)</td><td></td><td colspan="2"></td></tr>
<tr><td>Energy performance (PRE/POST)</td><td>The original heating demand was 235 kWh/m² y and the Primary Energy Demand was 256 kWh/m².</td><td colspan="2">The heating demand was reduced to 111 kWh/m² y and the Primary Energy Demand was 153 kWh/m².</td></tr>
<tr><td>Business Case: N2</td><td colspan="2">Comparison to BM</td><td>Note on compliancy with BM towards achievement of target</td></tr>
<tr><td>WHO</td><td colspan="2">This BC is a typical concrete-block detached villa from the 1950’s, a single family house with private owners. The lower floor (partially underground) used to have 3 rooms and a bathroom plus sauna. It has also access to the attached garage. The floor was excavated already before the renovation work started and the access to the upper floor was preliminarily blocked, i.e. the house was only lived in at the upper floor level.</td><td>Private building owners intend to renovate their property over a long period of time, targeting high level of energy efficiency and a certification of the results that will be achieved.</td></tr>
<tr><td>WHAT</td><td colspan="2">The business model provides the following advantages for the customer:
The individual building components had a different useful life duration. Investment has been done only for the components that needed replacement to allow spreading</td><td>Complete value proposition satisfied</td></tr>
</table>

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	the investment costs for modernisation measures over a longer period of time. • Certainty that the agreed energy standard will actually be achieved. • Increase in property value through independent quality assessment • A step-by-step modernisation may be developed even without taking out a loan, i.e. only equity may be used. For many building owners, this is the most important reason for carrying out modernisation measures in succession. • Full use can still be made of the remaining service life or residual value of components if necessary. In this way unnecessary additional investment costs can be avoided.	
HOW	The building owner in collaboration with the designer (Passive House Institute of Sweden) defines a planning for the renovation measures to be carried-out and a timeline of implementation. The building owner, in this case was directily involved in the planning of the renovation of the single apartment (step 1). The designer (Passive House Institute of Sweden) was the key player in this business model, because he/she was in charge of the whole renovation plan including different steps to be carried-out and the time schedule. The owner maintained an important role being responsible of the entire project. The different contractors were involved by the owner in the renovation project in successive phases, according to the initial plan. The design risk was shared between the owner and the designer, while different contractors assumed the construction risks associated to each of their tasks.	True
WHEN	First step of renovation began in Spring 2014 and finished in Autumn 2014. Other steps were planned to be carried aot respectively in 2016 and 2020.	Timing respected for step 1. Other steps not available.
WHY	The total investment cost for the retrofit of the apartment (step 1) was 44000 € (400k SEK). The 70% of the investment was funded by the European Commission, within the EuroPhit Project (see Appendix 1). There was a Tax-reduction scheme called ROT-avdrag,which is done yearly and therefore step-by-step had an additional benefit since the reduction can be applied over several years (tax-reduction up to 50 000 SEK/year on work carried out at the building by professional craftsmen).	In line with BM

Key features:

The main **technical challenge** was related to the insulation of the bottom floor, since the whole building sit on and in the rocky terrain and digging was too costly and time-consuming. For this reason the choice of high-performance insulating material was essential. Moreover, as in many places in Sweden, radon gas permeating from the floor and walls was an issue that needed to be addressed. Another issue regarded the presence of excessive moisture in the bathroom due to low level of thermal insulation. The first step of the renovation included the insulation of the lower level (floor and walls), allowing a good thermal insulation of the lower floor and giving the possibility of getting rid of the radon gas infiltration, making the lower floor usable again. It consisted in a new insulated floor slab (digging out concrete slab and a thin layer of rock

and re-fill with foam glass (~400mm) and woodfibre-slabs (100mm). A radon barrier under parquet and tiles was installed.
Another issue was related to the possibility of rising of district heating charges. For this reason the installation of a solar thermal system was considered. In some places, the prices on district heat also depend on the return flow temperature coming from the user – i.e. it might be beneficial to have only a few radiators left in action, which will do the room heating.
Concerning **organizational and financial aspects**, the single private owner, in collaboration with the designer (Passive House Institute of Sweden) planned the interventions and decided the budget for each of the refurbishment steps. In this way the owner was able to manage resources, spreading costs over a long period of time.

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Large residential building (multi-family) in Treviana Social Housing, Madrid, Spain

<table>
<tr><td>Images (PRE/POST)</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Energy performance (PRE/POST)</td><td colspan="2">The original energy demand was 316 kWh/m^2 y, where the heating demand was 150 kWh/m^2 y and the Primary Energy Demand 166 kWh/m^2.</td><td colspan="2">The energy demand after retrofitting is 202 kWh/m^2 y, where the heating demand was reduced to 47 kWh/m^2 y and the Primary Energy Demand 155 kWh/m^2.</td></tr>
<tr><td>Business Case:
S6</td><td colspan="3">Comparison to BM</td><td>Note on compliancy with BM towards achievement of target</td></tr>
<tr><td>WHO</td><td colspan="3">This BC is about a large residential building (multi-family) with 14 floors and 72 apartments built in 1963 in Madrid, Spain. It belongs to multiple owners and Spanish regulation requires that the renovation has to be approved by a minimum of 60% of the owners. New owners of a building apartment proposed the first retrofitting step. They decided to retrofit only the apartment before the community took the decision to realize other interventions.</td><td>Multiple private building owners planning complex renovation projects over a long period of time.</td></tr>
<tr><td>WHAT</td><td colspan="3">The business model provides the following advantages for the customer:
The individual building components had a different useful life duration. Investment has been done only for the components that needed replacement to allow spreading the investment costs for modernisation measures over a longer period of time.
Certainty that the agreed energy standard will actually be achieved.
Increase in property value through independent quality assessment
A step-by-step modernisation may be developed even without taking out a loan, i.e. only equity may be used. For many building owners, this is the most important reason for carrying out modernisation measures in succession.
Full use can still be made of the remaining service life or residual value of components if necessary. In this way unnecessary additional investment costs can be avoided.
Full use can still be made of the remaining service life or residual value of components if necessary. In this way one can avoid unnecessary additional investment costs.</td><td>Complete value proposition satisfied</td></tr>
</table>

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HOW	The private building owners (Treviana Social Housing Community) in collaboration with the designer (Vand Arquitectura) defined a planning for the renovation measures to be carried-out and a timeline of implementation. The private apartment owner in this case was directily involved in the planning of the renovation of the single apartment (step 1). The designer (Vand Arquitectura, highly expert in passive house design) was the key player in this business model. The owner maintained an important role being responsible of the entire project. The different contractors (Alther Technica) were involved by the owner in the renovation project in successive phases, according to the initial plan. The design risk was shared between the owner and the designer, while different contractors assumed the construction risks associated to each of their tasks.	The retrofitting project provided full renovation to a single apartment as first step of a full renovation. In parallel a planning for the complete step-by step refurbishment of the building was defined.
WHEN	First step of renovation began in January 2015 and finished in October 2015. Other steps were planned but renovation works did not start.	Timing respected for step 1. Other steps not started.
WHY	The total investment cost for the retrofit of the apartment (step 1) was 13726 €. The 70% of the investment was funded by the European Commission, within the EuroPhit Project.	In line with BM

Key features:
The main technical challenge in the first retrofitting step was at the design phase and it concerns the thermal bridges elimination as far as possible.
Construction details were designed focus on not only reducing the heating demand but avoiding the risk of condensation since the insulation is collocated on the inside and it was not possible to eliminate all the thermal bridges. Further steps have been taking into account during this first design period.
As only an apartment has been retrofitted as first step of the BM, a dedicated methodology has been created for this kind of project where a single apartment has been retrofitted first and years later the whole building or vice versa. The energy balance is calculated by the component method for the building, and later in order to avoid overheating an apartment for each orientation is analysed too. In this way, every owner who wants to retrofit his dwelling could take as reference the energy balance of the building and the single apartment with the same orientation.

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“St.St. Kiril and Methodius” Primary School building, Gabrovo, Bulgaria

Images (PRE/POST)		
Energy performance (PRE/POST)	For blocks A,B,C, the original heating demand was 142 kWh/m^2 y and the Primary Energy Demand 233 kWh/m^2. For blocks D, the original heating demand was 228 kWh/m^2 y.	For blocks A,B,C, the heating demand after the retrofitting was reduced to 17 kWh/m^2 y and the Primary Energy Demand 90 kWh/m^2. For blocks D, the heating demand was reduced to 116 kWh/m^2 y.
Business Case: E14	**Comparison to BM**	**Note on compliancy with BM towards achievement of target**
WHO	This BC consists of three similar block A, B and C. The Gym (Block D) connects to the other blocks by a corridor on the ground floor. The building, built in 1970, has a concrete structure with external brick walls (25 cm.) and concrete flat double ventilated roof. Since 2013, the school has been connected to the central gas heating. The public building owner (Gabrovo Municipality) intended to renovate its property over a long period of time, targeting high level of energy efficiencies and a certification of the results that will be achieved.	Public building owners planning complex renovation projects over a long period of time.
WHAT	The business model provides the following advantages for the customer: • The individual building components had a different useful life duration. Investment has been done only for the components that needed replacement to allow spreading the investment costs for modernisation measures over a longer period of time. • Certainty that the agreed energy standard will actually be achieved. • Increase in property value through independent quality assessment • A step-by-step modernisation may be developed even without taking out a loan, i.e. only equity may be used. For many building owners, this is the most important reason for carrying out modernisation measures in succession. • Full use can still be made of the remaining service life or residual value of components if necessary. In this way unnecessary additional investment costs can be avoided.	Complete value proposition satisfied

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	• Full use can still be made of the remaining service life or residual value of components if necessary. In this way one can avoid unnecessary additional investment costs.	
HOW	The public building owner (Gabrovo Municipality) in collaboration with the designer (Center for Energy Efficiency EnEffect) defined a planning for the renovation measures to be carried-out and a timeline of implementation. In 2013, the first Passive House in Bulgaria was built in Gabrovo – kindergarten Sun. With the “St. Kiril and Methodius” project the local authorities intended to create a model for refurbishment of old buildings to the level of the new NZEB definition. Choosing a school for a pilot project the Municipality wanted to set an example to be followed and to raise the awareness of the community. The designer (Center for Energy Efficiency EnEffect) was the key player in this business model, because was in charge of the whole renovation plan including different steps to be carried-out and the time schedule. The owner maintained an important role being responsible of the entire project. The different contractors were involved by the owner in the renovation project in successive phases, according to the initial plan. The design risk was shared between the owner and the designer, while different contractors assumed the construction risks associated to each of their tasks.	The municipality of Gabrovo has long traditions in the energy efficiency. In the last 6 years 7 schools and 15 kindergartens were improved with measures for EE on the standard level. Now the Municipality wants to be a leader in defining the new NZEB criteria.
WHEN	First step of renovation began in 2015 and finished in March 2016. Other steps were planned to be carried aot respectively in 2025 and 2050.	Timing respected for step 1. Other steps still to be developed.
WHY	The total investment cost for the retrofit of the building was 1,25 M€. The 70% of the investment was funded by the European Commission, within the EuroPhit Project.	In line with BM
Key features: The decision to apply a Step-by-Step model to the refurbishment was not only related to achieve a proper energy efficiency but even to improve the air quality. In fact, in this kind of buildings there is an air change rate of 0,6 1/h , this leads to uncontrolled use of the natural ventilation, higher heat losses and low quality of the air, especially in schools and kindergartens. The mechanical ventilation with heat recovery is a good decision to both: air quality and energy efficiency.		

1.1.1.4. Common factors and main recommendations

In all the three BCs, the following **common aspects** have been noted:

- **Difficulties in respecting the timeline of the step-by-step renovation**. The overall renovation plan was defined at the beginning of the project with a first step of intervention that often represent the main step in terms of energy performance improvement. The management role of the designer (planner) is essential to respect timing and to complete renovation.
- **Economic incentives from EU and/or local government have been used.** The support of EU funding appeared to be important feature for the BC under analysis.
- Step-by-step modernization permits to building owners with limited financial resources to **spread the investment costs for interventions over a longer period of time**

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The analysis of application of OSS BM based on Step-by-step approach provides potential recommendations/best practices for the whole process of refurbishment. The preliminary conclusions and recommendations are listed below according tot he following categories of refurbishment process.

Stakeholders evaluation

The central role of designers and planners is a foundamental point of the ste-by-step BM. Nevertheless, most of these retrofits are performed by small companies where no qualified technicians are involved. This means that, in most cases, the implemented solutions are not appropriated and the execution quality is poor. Carrying out high performance retrofits is of course made easier with the expertise of trained professionals.

In addition to training to professionals, it is also suggested to:

- Raise dissemination and awareness in neighbourhood associations to help owners to understand the effect of these simple measures and the quality that the works require.
- Encourage government to the creation of protocols to increase the quality of properties and the reduction of central heating and air conditioning use.
- To perform a strict control of the money to subsidise energy efficiency measures.

Project development and planning

Each refurbishment project should start with the holistic technical analysis of the building and involve a broad consideration of the specific site conditions (scanning opportunities). To this aim it would be relevant to a dedicated focus shall be done to the high quality of products used for the deep retrofitting of buildings. It is evident that the energy efficiency of the building is directly related to its high quality components. Nevertheless, it might be difficult to determine whether the performance of a given product is suitable for a specific standard or not. In many cases, product information is unclear or completely unavailable.Thus certified products shall be preferred.

Implementations

During the renovation work strong focus needs to be put on components quality and continuous monitoring of the quality of work. To this aim it would be relevant to:

- To use products and components that respond to the specific needs of step-by-step retrofit in order to achieve energy efficiency in a cost-effective way. For this reason it is fundamental to assure quality of building components and monitor their status in order to replace them according to their real life span. Renovation measures can be time and resource intensive, which is why they should be carried out when necessary.
- Collaborate closely with the contractor in order to have a good understanding of project´s goals.
- Introduce quality assurance procedures.

Documentation and monitoring

In order to ensure a successful delivery of Step-by Step BM, it is also suggested to include the deployment of “minimal monitoring” solutions within refurbishment. The term "minimal monitoring" should be understood to mean "an efficiency review of a building regarding its energy consumption using minimal effort". Through minimal monitoring in step-by-step refurbishments it is possible to validate the amount of energy saved through the completed partial modernisations in the same way as after a complete overall refurbishment, provided that the testing period after a retrofit step covers a meaningful time period and the measures

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produce a measurable relevant effect. The period of time required for validating the change in heating energy consumption is at least one complete heating period – with otherwise the same boundary conditions for usage. For example, if insulation of the top floor ceiling is carried out, then it is possible to examine how this affects the heating consumption during the following winter. If the windows are replaced in the next year, then again the following winter must be analysed in order to measure the success of that retrofit step.

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3.3.3. One-Stop-Shop provided by multi-disciplinary team cooperation – Energiesprong

Multidisciplinary team cooperation is a novel model of business where the project is carried out by a multi-disciplinary team in a cooperative manner. The multi-disciplinary team consists of partners with complementary competences, such as architects and designers, constructors, energy-efficiency experts, market and financial experts, technology suppliers, strategy and operations planners. Starting from the initial design phase, the team works together, in strict collaboration with the building owner, in order to select the most feasible intervention technologies and renovation measures to adopt, planning the whole renovation project according to customers' needs and desiderata, that consider also the costs related to planned works. The cross-fertilisation of gathering different actors together in an early phase of the renovation project permits to define a holistic approach to the renovation intervention. In this way sustainable and energy–efficient retrofitting based on innovative solutions for the life-time of the facility can be achieved, with an optimal control over the total costs of the renovation project and guaranteed efficiency performances.

The main idea in this business model is that the same team of consultants representing different design disciplines or expert areas will carry on with the project and produce the holistic design service for the building retrofitting.

A successful business model following this approach is the Energiesprong. Energiesprong is a whole house refurbishment and new built standard and funding approach. It originated in the Netherlands as a government-funded innovation programme and has set a new standard in this market. Within the several actors of a retrofitting project, Energiesprong plays the role of an Energy Renovation Facilitator, as it succeeded in bringing together different stakeholders as the public building owner (social housing associations) with private contractors.

The building owners are widely involved in this process as they take the financial risk because of the bank's loan, they invest in the energy refurbishment of the houses and they receive the rent and energy bills paid by the tenants until the loan is repaid. Moreover, there is a private company that has the assignment to rate the projects submitted by energy renovation companies as these latter have to guarantee: a few day delivery timetable, aesthetic attractiveness of the project and a 30-years insurance-backed energy performance. For what concerns the intervention, the changes interest the roof, the floor, the heating plant, the façade and the walls' insulation.

1.1.1.5. Business Model applied at Business Cases

Among the Business Cases identified, Energiesprong Business Model has been applied in two different BCs, one in Southern Europe and one in Western Europe. Applications are thereby provided, detailing what has been done, by whom and how.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 768287.

Social housing apartments and district single family houses, Nottingham, United Kingdom

Images (PRE/POST)		
Energy performance (PRE/POST)	The energy consumption was 97 kWh/m²/yr.	The energy consumption after retrofitting is 43 kWh/m²/yr.
Business Case: W12	**Comparison to BM**	**Note on compliancy with BM towards achievement of target**
WHO	This BC consists of ten homes (mix of terraced houses and bungalow) in Sneiton District, Nottingham that have been selected as part of a UK pilot of REMOURBAN[18] and Transition Zero projects to radically improve older houses using measure to save and generate energy. These properties ranges from single-family to multi-family houses, and in age, from 1900 to the 70s. A large number of the properties (65%) in the area are social housing, owned by Nottingham City Council (public owner) and managed on their behalf by Nottingham City Homes.	True. Multi-family buildings, with public owners, as in the case of municipalities' social housing.
WHAT	The following added value haves been provided: • Support of a wide network of professional multi-disciplinary team of experts, providing an holistic approach to the renovation project, whith high level of flexibility in the design phase • Owner directly involved in the definition of the intervention measures to be included in the renovation project • Optimal control of the total costs in an early phase of the project • Optimal integration of different measures thanks to cooperation between different actors involved in the renovation project	Complete value proposition satisfied

[18] http://www.buildup.eu/en/news/remourban-project-lighthouse-city-nottingham-working-sustainable-energy-future

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	• Total design and operational concept for retrofitting which covers life cycle of the building • Responsibilities and risks are shared between the members of the team	
HOW	The main stakeholders involved where: • NCC (Nottingham City Council), public owner • NCH (Nottingham City Homes), arms-length management organisation (ALMO), not-for-profit company • NTU (Nottingham Trent University), public university • NEP (Nottingham Energy Partnership), engineers and designers of energy efficient solutions • Nottingham Credit Union, capital provider • INFOHUB Ltd., SME ,real-time monitoring and control systems developer • SASIE Ltd., SME renewable energy company installers • Private owners • Solutions provider: Melius Homes • Design: Studio Prtington The inefficient communication between the different departments of the municipality resulted in delays. In addition, there was administrative confusion over sharing the responsibility, especially between the financial and urbanism departments. A cross-cutting smart city department was created in the municipality, designed to aid the implementation of these projects. The department did not function perfectly, but it has proved helpful in dealing with the administrative burdens.	Melius Homes takes responsibility for all aspects of the project from concept design to performance in use. Melius Homes has identified ways to speed up time on site and reduce costs for the rollout, leading to improvements to how the roof, wall panels and controls. The tenants were involved in developing the design brief, which means that the solution provider was able to include small additional items which made a big difference to the tenants' lives, such as the light tubes making stairs brighter, outside taps for watering plants and a door bell. Some communication problems occurred with municipalities creating delays.
WHEN	Works began in December 2017 and finished in 2018.	On time despite the delay.
WHY	The Energiesprong approach was procured based on a fixed price, evaluating the whole life cost and the design quality. Each home owner/private landlord received a grant towards the work, leaving a contribution of between 1400€ and 2536€ (£1260 - £2280) to pay, depending on the property type. Without the grant, this home improvement would normally cost upwards of 8900€ (£8000). To help householders pay for their contribution, NEP and Nottingham Credit Union introduced a zero interest loan. It meant the insulation was a more realistic option as the cost could be spread over a number of years without accruing extra costs. Nottingham received £5 million of EU Horizon 2020 research funding; £3m was for domestic energy	Part of the innovation was how the works were funded. The household payed an 'Energy plan', and the landlord (NCH) received an on-going income to fund similar works to more homes. The resident had a much more comfortable home, and a flat rate cost for energy, which will not rise significantly when energy bills rise. Melius Homes (UK) is already considering building a new factory for prefabrication. They probably will recruit between 15 and 25 people but also want to

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	efficiency measures for over 400 local homes, both social and private.	bring in automation in order to increase output.

Key features:

Within the UK BC, the inefficient communication between the different departments of the municipality resulted in delays. In addition, there was administrative confusion over sharing the responsibility, especially between the financial and urbanism departments. For this reason, a cross-cutting smart city department was created in the municipality, designed to aid the implementation of these projects. The department did not function perfectly, but it has proved helpful in dealing with the administrative burdens.

Moreover, during the project, the team has noticed equipment and goods costs increasing significantly between the initial bid and delivery stage, meaning that there have been financial pressures on achieving the required delivery activities of the project within the budget available. Government cuts and recruitment freezes have also put pressure on resources whereby changes in staff infrastructure have reduced the availability of personnel for the project. This was solved by hiring casual staff when necessary as well as consultants.

In addition, there were several positive aspects concerning technical, energetic and economic issues.

Concerning **technical** key features, the following may be underlined:

- Self-contained energy module - sited externally providing easy access for maintenance.
- Off-site manufacturing of a whole house energy retrofit that reduced cost, inconvenience to tenants and the time needed to complete an install.
- Efficiencies of scale: Offsite assembly and automation of insulated roof and wall cassette and energy modules. It is expected that the 2nd generation energy module will cost 35% less thanks to growing orders and making it more compact.

Also the following **energetic** aspects shall be highlighted:

- System and technology agnostic: the procured solution provider committed to delivering a performance that is long term guaranteed and defined as year-round comfort.
- Affordable warmth: energy and comfort per annum (to date this has been for as little as £600 for the first UK pilot) for 21/18DegC in lounge/bedrooms, 140L hot water a day and 2,300kWh/yr electricity for lighting, cooking and sockets.
- Near zero net energy retrofit in UK (<1,500 kWh/yr)
- Healthier: Prevents complications associated with fuel poverty including condensation and mould that can cause health issues and the underuse of rooms.

Last but not least, economic and administrative advantages were:

- Pays for itself: investment envelope aligned with expected lifecycle cost savings and revenues.
- Long-term whole house performance guarantee provided by the solution provider – reducing the risk of underperformance get with piecemeal improvements and guarantees.

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Typical brick individual house, Hem, France

Images (PRE/POST)		
Energy performance (PRE/POST)	The energy consumption was 301 kWh/m^2/yr (E)	The energy consumption after retrofitting is 76 kWh/m^2/yr (A)
Business Case: S7	**Comparison to BM**	**Note on compliancy with BM towards achievement of target**
WHO	This BC consists of 10 individual houses (2 groups of 4 houses and 1 group of 2 houses) in Hem, owned by the social housing association Vilogia. Vilogia is the first housing association in France to demonstrate 10 net zero energy (NZE) houses using the Energiesprong approach applied in the context of E=0 Project[19]. These houses are typical northern brick houses with two floors and four rooms built in 1952, with an initial energy performance of E. This first French refurbishment comes with a 25-years performance warranty on the energy performance.	Partially: single-family buildings, with public owners, as in the case of municipalities' social housing.
WHAT	The following added values have been provided: • Support of a wide network of professional multi-disciplinary team of experts, providing an holistic approach to the renovation project, whith high level of flexibility in the design phase • Owner directly involved in the definition of the intervention measures to be included in the renovation project • Optimal control of the total costs in an early phase of the project • Optimal integration of different measures thanks to cooperation between different actors involved in the renovation project • Total design and operational concept for retrofitting which covers life cycle of the	Complete value proposition satisfied

[19] http://www.nweurope.eu/projects/project-search/e-0-desirable-warm-affordable-homes-for-life/

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	building • Responsibilities and risks are shared between the members of the team	
HOW	The main stakeholders involved where: • Social housing association, Tenants and Owners: Vilogia • Buildings design and construction company: Rabot Dutilleul Construction • Design and installation of energy solutions: Pouchain • Engineering Company: Symoé • Design, fabrication and installation of prefabricated modules: Smart Module Concept • Architects: Redcat Architecture • Engineering Company: Nortec The chosen solution provider was Rabot Dutilleul, mainly because their whole team was passionate and vocal about Energiesprong. They were ready for the challenge and willing to put a lot of effort into the retrofitting project by mean of an innovative approach.	Vilogia is the social landlord who develops the most passive house certified projects in France (600 homes by 2020). Vilogia is committed to renovating by the year 2022 500 standard Energiesprong homes.
WHEN	Works began in April 2018 and lasts 3 weeks per building. The dwellings were delivered in May 2018. For the 10 housing units the construction lasted 3 months.	On time - 3 weeks at Energy 0 and guarantee this Energy 0 objective for 25 years.
WHY	Total cost: 1525 €/m² (design: 10500€, construction works: 121 k €/house, maintenance: 1100€ / house) – 1200000 in total Before the renovation, the global electricity bill for the ten dwellings amounted to 1 500€ per year and each tenant had to pay 400€ in rental charges. After renovation, the electricity bill stands at 600€ and the rental charges have been set at 700€. The rent remains fixed. Incentives/ grant received: 51000 €/house for the construction work (Interreg NEW); This project also received a cofunding ADEME / Caisse des Dépôts & Consignations to performed some preliminary studies. Nonetheless the price was still not on par with the Netherlands but they tried really hard to bring it down, for example by consulting diverse solution providers and analysing the impact of different components to find things they could change. Designing, fine-tuning and pricing is an ongoing process.	The cost of this first EnergieSprong demonstrator was high as it was a first trial in France. The long term objective is to achieve these refurbishment at standards costs or at least at a cost of 75000 € / 70000 € per home for individual houses and 55000 € per home for buildings, which will be possible as the demand goes higher and the sector gets structured. It took nearly 1000 homes in 5 years in the Netherlands to reduce costs by 50%.
Key features: In March 2016, Energiesprong was launched in France. The team was hosted by the sustainability consultancy GreenFlex, specialised in helping organisations to accelerate their social and		

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environmental transition, GreenFlex has set up a market development team of 7 people to adapt and implement the Energiesprong approach with local stakeholders. Operene in France has secured match funding for an innovative 5-year R&D project. This promises to take the technical specification used in the early pilots to a new and even higher level of sustainability for the French market. Energiesprong France has received financial support from: • Innovation programme Horizon2020 / Transition Zero • Interreg North-West Europe / E=0 • ADEME: The French Environment and Energy Efficiency Agency. • Caisse des Dépôts, a French semi-public financial institution that plays a major role in financing social housing, energy transition & smart city developments in France.

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1.1.1.6. Common factors and main recommendations

The common factors emerging from the BC analysis were the following:

- **Dedicated project management** to represent Energiesprong
- **Collaborative approach to procurement** for the ultra-low energy homes – built a good relationship with the contractors
- **Right infrastructure** in place e.g. District Heating to build on
- **Citizen engagement strategy** already in place from which to build on

The analysis of application of OSS BM based on Energiesprong approach provides potential recommendations/best practices for the whole process of refurbishment. The preliminary conclusions and recommendations are listed below according tot he following categories of refurbishment process.

<table>
<tr><td></td><td>Stakeholders evaluation</td></tr>
<tr><td colspan="2">The philosophy of EnergieSprong aims to associate tenants from the launch of the project so that the various stages are held at best. It has been noted how important it was to ensure good communication and overall project understanding. To this aim, it was useful to:
Establish monthly team meetings, engaging with all local partners working within the project across all the various strands. After renovation, tenants were accompanied for one year to familiarize themselves with a new way of living places (maintenance of ventilation, monitoring of heating and cooling systems).
Reduce significantly construction time to facilitate the acceptance of the work. In this context, it shall be important to stimulate the supply chain, finding way to get builders to think more like product manufacturers, how to attract better component suppliers and how to achieve efficiencies of scale.</td></tr>
<tr><td></td><td>Project development and planning</td></tr>
<tr><td colspan="2">Usefull insights might be:
Early tenants' engagement also during the project is key – tenants have a valuable contribution to make in the shaping of a housing retrofit solution, although expectations need to be managed.
Early engagement with planners, find out how they see the local neighbourhood developing and design the external aspects in line with their future vision</td></tr>
<tr><td></td><td>Implementations</td></tr>
<tr><td colspan="2">During the works, resources shall be a constant point of contention, with the number of personnel and cash resources required during the implementation of the project often different to those anticipated at the planning stage. This can be largely due to industry cost increases as well as staff reductions. However, such costs need to be anticipated and accounted for in funding budgets, and internal potential funding sources understood throughout the length of the project. It is essential also that the project has support throughout the organisational hierarchy, with an appointed project sponsor ensuring communication to management.</td></tr>
<tr><td></td><td>Documentation and monitoring</td></tr>
<tr><td colspan="2">Along the project monitoring, it is suggested to:
Pursue a strong communication campaign, providing the benefits of the project by mean of examples of best practices implemented in other similar projects to overcome the difficulties encountered when</td></tr>
</table>

trying to explain the benefits of the project in attracting private investment. • Perform a a constant costs reworking, matching the internal funding with the rising costs of project delivery ensuring that the project can be delivered whilst also working under budget pressures.

3.3.4. Energy Performance Contracting

The EPC model is based on delivering energy savings compared to a predefined baseline. In the Energy Performance Contracting (EPC) model, an Energy Service Company (ESCO) enters into arrangements with property-owners to improve energy efficiency of their property by implementing various measures. Thus, the application span of Energy Performance Contracting involves the entire building as one incorporated energy-consuming unit. In other words, under an Energy Performance-Contracting (EPC) business model, an Energy Service Company guarantees energy cost savings (also labelled as 'Negawatt-hours') in comparison to a historical (or calculated) energy cost baseline. **For its services and the savings guarantee, the ESCO receives performance-based remuneration in relation to the savings it achieves**. Generally, savings achieved can only be measured indirectly as difference between consumption before and after implementation of the EE and RE measures (relative measurement: savings = baseline – ex post-consumption).
The standard scope of services encompasses the entire building. RET may play a role but with most EPC projects the focus is on the implementation of energy conservation measures. EPC models run under long-term contracts of **typically ten years**, depending on the payback time of the energy savings measures and the specification of the building owner. ESCOs can also finance or arrange financing for the operation, and their remuneration is directly linked to demonstrated performance regarding the level of energy savings or energy service.
In conclusion, **more than a funding model, an EPC is a programme of practical engineered energy efficiency measures that are implemented in buildings to deliver real energy savings such as HVAC, lighting, controls and building fabric improvements**. In addition, to ensure the building is used in the most efficient way, building occupants receive training on energy efficiency practices.
Indeed, when measuring savings through a comparison between a baseline and post-retrofit energy costs, two major difficulties may occur:

- The baseline itself may be difficult to determine with enough accuracy due to a lack of availability of historic data (e.g. from bills or meters).
- The determined energy cost baseline is not a constant but subject to changes in climate conditions (e.g. ambient temperatures, solar radiation etc.) and in energy prices. Besides, utilization of the building may change. These changes need to be taken into account when calculating energy cost savings. Especially the changes in utilization may cause considerable difficulties for the ESCO and the facility owner in adjusting the baseline.

1.1.1.7. Business Model applied at Business Cases

Among the Business Cases identified, this Business Model has been applied in two different BCs, both in Southern Europe. Applications are thereby provided, detailing what has been done, by whom and how.

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Multi property residential buildings, Torrelago district, Laguna de Duero, Spain

Images (PRE/POST)			
Energy performance (PRE/POST)	The energy consumption was 139 kWh/m²/yr.	The energy consumption after retrofitting is 89 kWh/m²/yr in total.	
Business Case: S4	**Comparison to BM**		**Note on compliancy with BM towards achievement of target**
WHO	This BC consists of the renovation of Torrelago district that was implemented in the framework of the FP7 funded CITyFiED project[20]. Torrelago district involves 31 private multi-property residential buildings (1488 dwellings), built in the 1970s–1980s, more than 140000 m² and 4000 residents involved. Former conditions of the district were very low in terms of efficiency, comfort and costs, which fostered the intervention.		The main prerequisite for having EPC is the project size (energy cost baselines can be set at 100,000 €/y). Being a district the target has been achieved.
WHAT	The key benefits include risk transfer, the ability to modernise the building's energy infrastructure without necessarily having the funds and accessing external expertise. The key focus was on saving energy at the point of use first, before optimizing the supply of that energy. For many potential customers financing is the most attractive part of EPC services for public buildings.		Almost complete value proposition satisfied.
HOW	The owner were private and multiple. The owners are organized into Communities, which charge energy bills to the home owner through monthly Community fees. • VEOLIA: team leader. District Heating and Smart Grid Interventions • 3ia: Building retrofitting intervention • Ayuntamento de Laguna de Duero: Urban Planning, permit and licenses • Acciona: building retrofitting definition and modelling, BIM modelling • Tecnalia: district heating optimization, modelling and simulation		Initial difficulties for convincing all the tenants.

[20] http://www.cityfied.eu/

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	There was an initial opposition of a minor group of people that wanted to stop the project, but finally the project could continue and finish in record time with the acceptance of the majority of the neighbours. The results that were achieved caused a very favourable evolution in the opinion of those owners who were more reluctant and sceptic at the beginning.	
WHEN	Works were on scheduling	In line with BM
WHY	The investment cost for the intervention was 738 €/m², making a total of 4251000 € excluding VAT (about 2 million for energy measures), about 52480 €/flat. The EU contribution was equal to 8M€ in total. The financial return for the project was more than 30 years. This is relatively long, but as a demonstration for a non-mature innovation under testing it could in fact be considered as short and could improve.The rental value after refurbishment would also positively affect the return on investment.	Relatively long return of the investment
Key features: In Torrelago district more than 4000 people benefitted directly from the renovation project actions, whose success relied on the truly collaboration between all the partners and on the involvement of the residents (building owners) from the very beginning of the project. The economical impac saw new jobs created in the local context, with more than 50 unemployed local residents who received technical training and were hired to work on the renovation of the building facades.		

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Social Housing Apartments, Pieria, Greece

<table>
<tr><td>Images (PRE/POST)</td><td></td><td colspan="2">n/a</td></tr>
<tr><td>Energy performance (PRE/POST)</td><td>The energy consumption was 198,5 kWh/m²/yr.</td><td colspan="2">The energy consumption after retrofitting is 134 kWh/m²/yr in total.</td></tr>
<tr><td>Business Case: S5</td><td colspan="2">Comparison to BM</td><td>Note on compliancy with BM towards achievement of target</td></tr>
<tr><td>WHO</td><td colspan="2">This BC consists of Social Housing Apartments, located in the North of Greece, built in two different periods, namely in 1977 (building permit of 1974) and 1981 (building permit of 1978). The renovation of the buildings was undertaken during the ECOLISH project aimed to investigate the possibilities for energy efficient retrofitting for low incomes and social housing by using the possibilities of energy performance contracting (EPC) and energy exploitation by ESCO’s.
The retrofitting has been carried out in two steps:
- First stage of the retrofitting: the retrofitting included the installation of heat cost allocators and the conversion of each dwelling to an autonomous heating unit. Techem took over the energy management of the blocks. The inhabitants will pay their bills to Techem who will be responsible for the collection and the monitoring of the energy consumption of each flat.
- Second stage of the retrofitting included all the other energy measures, namely the replacement of the existing boilers, the insulation of the pipes, the installation of external roof insulation, and the paintings of the blocks externally with paints with high solar reflectance.</td><td>The main requirement for having EPC is the project size (energy cost baselines can be set at 100,000 €/y). These buildings contain 249 apartments and 10 shops and thus perfectly meets the requirement.</td></tr>
<tr><td>WHAT</td><td colspan="2">The key benefits included risk transfer, the ability to modernise a building’s energy infrastructure without necessarily having the funds and accessing external expertise. The key focus is on saving energy at the point of use first, before optimizing the supply of that energy.
For many potential customers financing is the most attractive part of EPC services for public buildings.</td><td>Almost complete value proposition satisfied</td></tr>
<tr><td>HOW</td><td colspan="2">The owner were private and multiple. The owners were the inhabitants for the apartments and the Workers Housing Organization for the communal areas. Indeed, despite low</td><td>It was not easy for the Pieriki Anaptixiaki contact people to make</td></tr>
</table>

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	income households, all residents own their flat. Only the shops and communal areas were still owned by the Workers' Housing Organisation (Organismos Ergatikis Katikias), which also built the entire housing estate. All costs and expenses for any refurbishment work must therefore be borne by the residents. Only in special cases will the Workers' Housing Organisation cover the costs. The Workers' Housing Organisation targets low income active and retired workers who contribute to the Workers' Housing Organisation via social insurance, meaning that the number of unemployed people in the pilot scheme settlement is low in comparison to other low income areas. However, more than 60 percent of residents earn less than the national average; it is possible that undeclared income complements the official revenue in several households however. The ESCO involved was Techem Energy Services GmbH & Co, a leading global energy service provider for the real estate sector and private homeowners. In the Greek pilot scheme location, energy performance contracting has been proposed between Techem Greece as the energy service company (ESCO) and the occupants of the selected blocks. Contracting components shall include insulation of the roofs, replacement of the boilers and insulation of the heating pipes. All radiators fitted with a thermostatic valve and heat cost allocator. The residents could then control the heating in their own flat. Furthermore the external walls and roofs have been painted with high solar reflectance paint to reduce solar warming in the summer.	contact with the residents and convince them to improve the flats and buildings. No regular owner meetings were set up to decide on shared occupant issues. Only in a few blocks have common managers been appointed for a building. The involvement of the Municipality has been essential not only for the communication campaigns with the residents but also easing the administrative and legal processes.
WHEN	Works have been done in 2009	Delay due to administrative issues
WHY	The ESCO's interest (Techem) to participate in the project was multi-level, lying in three different levels: local, national and European. At local level ESCOs have the opportunity to contact the pilot location and with the support of the local actor to discuss with the occupants the potentiality of signing a local contract. Detailed examination and analysis of the location was offered. At national level, although the existing legal framework and the market requests were known to ESCOs, coding of the existing framework could provide an important tool to them. At European level, exchange of knowledge between similar companies is always an important toll of knowledge development. Moreover, the local conditions in different countries could also provide important feedback to all participants ESCOs. The occupants obtained their energy from Techem and payed the bills they received from this company. They shall pay off the investments made by Techem with a fixed price and the costs of the energy purchased with a variable fee. Techem is monitoring the heating and cooling costs and sharing these	No legalization on ESCO's yet and thus there were more delays on ESCO's legalization and dispersion of competences. Moreover, low energy luminaires should be funded by the occupants themselves, as in the case of Greece, because of legal reasons, ESCO cannot undertake this task because it is not legal to have access and control on the use and maintenance of items inside the property.

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	results with the occupants several times a year. The residents shall pay less rather than more for their energy needs. Should occupants wish to decrease their energy demands beyond this, they must pay for the investments themselves. Profitable measures included the replacement of single-glazed windows with double glazing and the use of energy-saving light bulbs and energy-efficient ceiling fans. Energy performance contracting as the proposed financing scheme has uncommon in Greece, but it offers occupants financial and procedural advantages over the traditional financing schemes.	
Key features: Key features for the Greek BC was the involvement of the tenants. The first step was a letter to all residents providing them with information about the project and the national and international organisations involved. The letter was handed out face-to-face, providing a first opportunity to talk to the occupants. It was also a chance to experience the residents‘ initial reactions. The next step was the organisation of a first meeting for the occupants with the help of three block managers.		

1.1.1.8. Common factors and main recommendations

In all the selected BCs there was a significant discrepancy between the designed (calculated) and the real (monitored) total energy use in buildings. This is not only the situation of these BCs but it is a phenomenon that is recognized in general. Although building regulations have been strengthened in EU countries with respect to energy efficiency the real energy use is not decreasing at the same rate and in many occasions even is increasing. Buildings and their systems improve, but building usage and activities in buildings can lead to increasing energy consumption. This can form a major thread for the implementation and the effectiveness of the final 20-20-20 targets set by the EU. The reasons for this discrepancy are generally poorly understood, and often have more to do with the role of human behavior than the building design.
Typical characteristics and barriers of EPBD based Energy Performance Ratings are: i) EPR’s are (public) instrument of the government for reducing CO2-emission on a macro-level (for obtaining a building permit) as on micro scale occupants’ behavior is dominant in the final energy use; ii) Only look at Building Regulation related aspects but not at human behavior; iii) The starting points are based on reasonable averages, general and sometimes arbitrary; iv) The costs are for property developer or housing companies, the benefits are for the occupants who lead in the market to houses that just/only match the building regulations but don’t have any additional or optimized energy efficiency measures; v) It cannot be used in the selling and financing of new build houses or for financing energy efficiency measures in existing houses; therefore the potential financial benefits are not utilized or exploited.
To overcome these barriers a total chain approach is recommended relying on three pillars:

1. prediction that is accurate and robust enough.
2. contracting, financing and guarantee.
3. monitoring.

The basis is a solid methodology to calculate a reliable relation between energy saving measures and the prediction of total energy consumption. An understandable output for end-users such as energy costs in Euros is necessary. Then, guaranteed energy saving predictions can be used for contracts between real estate developers or housing companies and the end-users. This should concern the total energy use and not only building regulations related energy use. In such contracts the predicted energy use will be compared by monitored energy use, by smart metering. These necessary methodologies should be developed to improve the reliability of predicted energy consumption, and should be compared with smart metered energy consumption and from that the right instruments for communication. Commitment by the total chain can be accomplished in three ways:

1. energy guarantee contracts for end-users, in which maximum energy consumption of their homes are

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contracted, including responsibilities and bonus/malus systems;

2. performance contracts in the total chain, between suppliers, installers constructors and principals (real estate developers, housing companies;)
3. new improved finances, based on the improved reliability of predicted energy, such as improved conditions for mortgages or loans for investments in energy efficiency measures.

This approach could take away one of the major barriers for energy performance contracts and ESCOs: i.e. the uncertainty of the real energy savings and therefore the uncertainty of allocation of the energy saving benefits to investments. This approach could offer also opportunities for the development of energy saving technologies that take into consideration as well the building related as well as the user related energy use, and the prediction of both expected energy use in new and renovated buildings and cost-benefit relation of energy saving measures to increase implementation of energy contracting and management as well as financing construction in which benefits of savings will be allocated to investments.

Finally, the analysis of application of Eenrgy Performance Contracting provides general recommendations/best practices for the whole process of refurbishment. The preliminary conclusions and recommendations are listed below according tot he following categories of refurbishment process.

<table>
<tr><td></td><td>Stakeholders evaluation</td></tr>
<tr><td colspan="2">Roles of different players in the BM shall be valorized:
Municipalities can play an important role in establishing revolving funds and organising occupants for example. The political lifespan and different political interests can prove an issue however.
ESCOs could play a new and important role. The residential sector and even individual homeowners could be a new and interesting business area. Several financing schemes are possible but those with mortgage and revolving funds are preferred.
Occupants shall not constitute a bottlenock for the building retrofitting but may become an active stakehlders by organising themselves and forming legal entities. This may be a timeconsuming process but one, which is extremely important if any results or commitments are to be achieved. A multilevel, bottom-up approach can solve the problems being faced. Occupants welcome support as soon as they realise that it is well-intentioned and recognised, but may be reluctant to accept external help. It is important to provide a balanced set of energy-saving measures. They should also appeal to the target group and offer robust saving potential.</td></tr>
<tr><td></td><td>Project development and planning</td></tr>
<tr><td colspan="2">Each refurbishment project should start with the holistic technical analysis of the building and involve a broad consideration of the specific site conditions (scanning opportunities). According to the selected BC it is suggested that:
The most efficient the technologies are, the least impact on energy consumption and the environment will be produced. For that reason, if any future retrofitting project is limited by the initial investment the technologies should be selected not only in terms of energy savings and CO_2 emissions, but also through a life cycle cost analysis.
Energy savings by improving the building envelope are more stable than upgrading the building services. Architectural improvements shall be therefore preferred, but not commonplace for ESCOs. Improvement of the building envelope often requires large investments, which may prove disadvantageous in parts. The long amortisation period should match the extended lifespan of the building. A real estate expert could quantify the benefits of the increased building value that renovation would bring before any work is carried out.</td></tr>
</table>

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<table>
<tr><td></td><td>Implementations</td></tr>
<tr><td colspan="2">It is recommended that the offer from the ESCO to a well-organised group of homeowners for EPC should include a balanced set of technical measures, which suit the target group, and a clear plan of how a group that doesn‘t normally have access to any financial means can finance these. Technical measures themselves are quite common building practice, but risk allocation in energy savings and financial exploitation are still a big challenge. In practice, the savings depend a great deal on occupant behaviour and may not meet expectations. Sharing of this risk requires expert attention and clear instructions for the occupants.
Thus, also from a technical point of view, the most important lesson was the need to work in a truly cooperative approach.
Since the very beginning, project representatives shall carry out a number of workshops with the residents about the actions deployed for the project. Participants may thus have the opportunity to address various technological and non-technological solutions designed to cut energy consumption and improve comfort, as well as the effects these could have on residents. During the workshops, partners are able to capture the needs of residents, and look into how to deliver the appropriate technical solutions.</td></tr>
<tr><td></td><td>Documentation and monitoring</td></tr>
<tr><td colspan="2">Concerning the energy monitoring, it is worthcoming to remember the importance of dynamic data for the energy system optimization as well as the importance of real data for reliable assessment and decision-making.</td></tr>
</table>

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3.3.5. Add-on Business Model

Add-on Business Model is a renovation strategy intended as the construction of one (or a set of) Assistant Building unit(s) - like aside or façade additions, rooftop "vertical" extensions or even an entirly new side-building construction - that are added to the existing building to achieve nearly zero energy standards. The creation of these Assistant Buildings aims at reducing the initial investment allocated for the deep renovation of the existing building creating an upgrading synergy between old and new.

When combined with the adoption of EE or RET measures, volume additions are interesting type of intervention since they instantly produce new, commercially valuable dwelling area which could compensate the costs of energy-optimisation. In this way the building renovation process should be attractive to financial actors and decision-makers (financial institutions, developers, managers, householders, policy-makers, buildings owners and associations) and also have important environmental and social impacts.

The renovation process in this BM is performed through the addition of volume to the building being it a rooftop "vertical" extension, a façade addition or even a side building. Usually this type of model utilises industrialised construction methods and prefabricated elements in order to shorten project time and reduce the impact for tenants.

The added volume and dwelling area consist of a bonus, a complementary economic instrument for the investors (real estate investors, construction companies in conjunction with ESCO, etc.) also considering the possibility of creating a risk fund with the real estate surplus generated by the new building, that could cover the risk of arrearage for the inhabitants in paying the bills. The Add-on BM may act as an attractor for private sector financing, playing an extremely important role, in particolar in contexts of scarce private finance where the search for affordable up-front investments is crucial.

1.1.1.9. Business Model applied at Business Cases

Among the Business Cases identified, this Business Model has been applied in four different BCs, one in Northern Europe and three in Western Europe. Applications are thereby provided, detailing what has been done, by whom and how.

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Student Apartment, Oulu, Finland

Images (PRE/POST)		
Energy performance (PRE/POST)	The total energy consumption was 115 KWh/year. The original heating energy was 148 kWh/m^2 y.	The total energy consumption after retrofitting is 48 KWh/year. The heating demand is 30 kWh/m^2 y.
Business Case: N3	**Comparison to BM**	**Note on compliancy with BM towards achievement of target**
WHO	The BC is a student apartment in Oulu, Finland, owned by PSOAS Student Housing Foundation of Northern Finland, one of five student apartment buildings in the housing cooperative. The building has 8 apartments, and was built in 1984.	Large residential building in the need of renovation. Public building owner.
WHAT	The renovation process is performed through the addition of volume to the building being it a façade addition. The intervention used industrialised construction methods and prefabricated elements in order to shorten project time and reduce the impact for tenants. The added volume and dwelling area consist of a bonus, a complementary economic instrument for the investors (real estate investors, construction companies in conjunction with ESCO, etc.) also considering the possibility of creating a risk fund with the real estate surplus generated by the new building, which could cover the risk of arrearage for the inhabitants in paying the bills.	Complete value proposition satisfied
HOW	The renovation has been developed and managed by a synergic work involving a group of experienced architects and design planners working on the subject of deep renovation with a particular attention to building quality and architecture regeneration. A constant involvement of final users was fundamental to correctly target their needs and provide	True

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functional and demand-responding solutions. The involved stakeholders are provided in the table below:

Role	Name	Brief	Design	Construction	Monitoring
Building owner	PSOAS	X	X	X	X
Condition analysis	WSP Finland	X			
Architect	M3 Architects		X		
Energy specialist	NCCFI (Optiplan)		X		X
Structural engineer	Insinööritoimisto Putkonen		X		
HVAC engineer	Insinööritoimisto Taltekon Oy		X		
Electrical engineer	Oulun Sähkö-Aika Oy		X	X	
Contractor	NCC Rakennus Oy	X	X	X	
Subcontractors	Suomen Rakennustuote Oy, Fidelix Oy			X	X
University	Aalto University	X	X		X
Airtightness and thermal test	Cramo Finland Oy				X

WHEN	The retrofitting intervention began on site in August 2012 and finished in February 2013.	In line with BM
WHY	The total investment cost for the retrofit of the building was 1430000 €. The refurbishment was developed with PSOAS own funding and supported by EU FP7 project funding. The EU funding was critical for research and development work, and follow-up monitoring of the project. However, the total refurbishment was expensive, with one third of the costs caused by energy retrofit and total construction costs comparable to new building at passive house level. The financial analysis shows that the profitability of the project is not given due to the high investments in comparison to the low energy cost savings. The result was an energy efficient building to the standard of a new building with a renewed 50 year life expectancy, achieved with lower embodied energy due to the recycling of existing structures. Nevertheless, compared with the rest of the Europe, the Finnish thermal resistance requirements for new buildings have been notably stricter for quite some time. Because the Finnish building stock is relatively young, energy performance has been taken into account when the current buildings were built. The amount of energy consumed in buildings is highly influenced by Finland's northerly location, and because of this, measures aiming at decreasing the amount of energy needed for heating are usually cost effective.	Missed achievement of profitability has been balanced by non-monetary benefits

Key features:

One of the key feature was the direct engagement of tenants.

The investment in deep refurbishment delivered a positive rise in living standards and comfort for tenants with the newly landscaped yard constructed, larger balconies, and greater indoor comfort balanced with enhanced energy efficiency. Nevertheless, the owners (PSOAS) did not anticipate the amount of

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disturbance that was created by the phasing of ongoing renovations around the building's exterior, and received complaints from tenants due to unexpected remedial work after the refurbishment. The post-occupancy tenant questionnaires provided valuable insight into understanding the disturbance during the refurbishment process. Residents gave feedback on noise and dust from the renovations of adjacent buildings. The need for improved communication with tenants throughout and after the refurbishment process was demonstrated.

Based on the experience in this demonstration with post-refurbishment repairs, and experience by NCCFI (the energy specialist contractor) in resident training there was a need for tenant education and communication at all phases to reduce complaints and disturbances, especially with post-retrofit repairs. Residents tolerate more disturbances and more variations in indoor climate when they understand the reasons. Indoor climate and user comfort were important topics for residents training, to explain different needs, personal preferences and satisfaction (draft, ventilation, surface temperature, humidity, heating and the influence of indoor furnishing). Increasing attention should be given to explain how heat recovery mechanical ventilation works, how to save electricity, how to avoid heat losses, how cooking and hot water use impacts on residents energy use, and why it is important to sort waste and recycle.

Another important remark concerning the BC is about the **replication potential**. The typology of the student apartment may be seen in other building typical of the era (1946- 1979), up to the mid 1980’s, which represent the bulk of Finnish industrialized housing production from the post-war era. The Oulu building was a good practical example of energy efficient refurbishment and buildings adapted for today’s needs in cold climates. Detailed monitoring provided insight for research, and will allow construction practice to improve the design of retrofit facades through building physics analysis. Learning from empirical evidence of construction process has been documents, and analysis has been made of the cost structure and potential to optimize benefits and added value. Lessons from this building have been already used on the four neighboring houses owned by PSOAS. The replication potential is to be exploited for the future retrofit of prefabricated concrete element housing in post 1960’s Finland.

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Residential multi-storey buildings, Munich, Germany

<table>
<tr><td>Images (PRE/POST)</td><td></td><td colspan="2"></td></tr>
<tr><td>Energy performance (PRE/POST)</td><td>The original Primary Energy Demand was 340 kWh/m^2.</td><td colspan="2">The energy demand after retrofitting is 22 kWh/m^2 y.</td></tr>
<tr><td>Business Case: W10</td><td colspan="2">Comparison to BM</td><td>Note on compliancy with BM towards achievement of target</td></tr>
<tr><td>WHO</td><td colspan="2">This BC is a residential multi-storey buildings consisteing of two blocks built in 1954. The buildings, owned by the public housing company GWG München, represented uniform standard concrete brick blocks built in the post-war decade of the 1950s. The buildings have been fully retrofitted, including the replacement of the attic by an additional floor to create more rental space, increasing the Net Dwelling Area up to 3.323 m^2 (originally 2.012 m^2, + 65 %, phase 2 + 155 %).</td><td>Large residential buildings, with public owner</td></tr>
<tr><td>WHAT</td><td colspan="2">The renovation process has been performed through the addition of volume to the building being it a rooftop “vertical” extension, and a façade addition. The renovation used industrialised construction methods and prefabricated elements in order to shorten project time and reduce the impact for tenants.
The added volume and dwelling area consist of a bonus, a complementary economic instrument for the investors (real estate investors, construction companies in conjunction with ESCO, etc.) also considering the possibility of creating a risk fund with the real estate surplus generated by the new building, which could cover the risk of arrearage for the inhabitants in paying the bills. The Add-on BM may act as an attractor for private sector financing, playing an extremely important role, in particular in contexts of scarce private finance where the search for affordable up-front investments is crucial.</td><td>Complete value proposition satisfied</td></tr>
</table>

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STUNNING

<table>
<tr>
<td>HOW</td>
<td>The renovation is developed and managed by a synergic work involving a group of experienced architects and design planners working on the subject of deep renovation with a particular attention to building quality and architecture regeneration. A constant involvement of final users was fundamental to correctly target their needs and provide functional and demand-responding solutions. The involved stakeholders are provided in the table below:
<table>
<tr><th>Role</th><th>Name</th><th>Brief</th><th>Design</th><th>Construction</th><th>Monitoring</th></tr>
<tr><td>Building owner</td><td>GWGM Städt. Wohnungsges München mbH</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>Architects</td><td>KLA Kaufmann Lichtblau Architekten BDA</td><td>X</td><td>X</td><td>X</td><td></td></tr>
<tr><td>Energy experts</td><td>KLA Kaufmann Lichtblau</td><td></td><td>X</td><td>X</td><td></td></tr>
<tr><td>Structural engineer</td><td>IB Merz Kley Partner IB bauart Konstrukt.</td><td></td><td>X</td><td>X</td><td></td></tr>
<tr><td>HVAC engineer</td><td>IB EST Energie-System-Technik</td><td></td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>Contractors</td><td>Fa. Müller Holtzbau, Fa. HTR Baumeister, Fa. Zistler HLSE</td><td></td><td>X</td><td>X</td><td></td></tr>
<tr><td>University</td><td>TU - München</td><td></td><td></td><td>X</td><td>X</td></tr>
</table>
</td>
<td>True</td>
</tr>
<tr>
<td>WHEN</td>
<td>The renovation of the buildings, performed in the framework of the E2Rebuild project, started in July 2010 and the building was fully occupied in the summer of 2012.</td>
<td>Timing respected.</td>
</tr>
<tr>
<td>WHY</td>
<td>The funding was provided by KFW, dena, LH München/ E2ReBuild (see appendix 1) and Europe in the framework of FP7.
The approval documentation and technical design specifications resulted in a public tendering which finally led to a contract with the cheapest providers of all crafts, including the main role of the timber manufacturer.
Building Costs: 950 €/ m² GFA (gross, DIN cost groups 300/400, min. low-e fund. ca. 20 %).
The financial analysis shows that the profitability of the project is not given due to the high investments in comparison to the low energy cost savings. This however did not reflect non-monetary benefits that might occur through the implementation.</td>
<td>Missed achievement of profitability has been balanced by non-monetary benefits</td>
</tr>
<tr>
<td colspan="3">Key features:
From the technical point of view, the planning team and the building contractor underlined that the theoretical innovation potential of construction methods and processes was absolutely case-specific and could only succeed if done step by step, according to the competence, will and potential of the contractors.</td>
</tr>
</table>

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Single family houses and terraced houses in Kroeven Roosendaal, Netherlands

Images (PRE/POST)		
Energy performance (PRE/POST)	The original energy demand was 136,7 kWh/m^2 y.	The energy demand after retrofitting is 43,1 kWh/m^2 y.
Business Case: W11	**Comparison to BM**	**Note on compliancy with BM towards achievement of target**
WHO	This BC is about the energy renovation of terraced houses built in the 1960s. The overall objective of the project is to achieve affordable and healthy homes in an attractive area, which can be used for another 40-50 years. Therefore passive renovation has been chosen as the main strategy to achieve a very low heat demand and thus affordable heating costs and a good indoor environment The demonstration concerns 50 houses, out of a total of 246 passive renovation and 90 new passive houses. Prefabrication of façade and roof elements have been used as the main means of renovation, with the aim of reducing the disturbance of tenants, constant and high quality and good energy performance. Moreover solar collectors were added for the production of domestic hot water.	Multiple private building owners (district)
WHAT	The renovation process is performed through the addition of volume to the building being it a façade addition. The renovation intervention used industrialised construction methods and prefabricated elements in order to shorten project time and reduce the impact for tenants. The added volume and dwelling area consist of a bonus, a complementary economic instrument for the investors (real estate investors, construction companies in conjunction with ESCO, etc.) also considering the possibility of creating a risk fund with the real estate surplus generated by the new building that could cover the risk of arrearage for the inhabitants in paying the bills.	Complete value proposition satisfied

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<table>
<tr>
<td>HOW</td>
<td>The suppliers did work as equal contractors instead as subcontractor under a main contractor. The team collaboration developed into a streamlined process, in particular in the phase of the mounting of façade and roof elements.
Tenants have played a key role in the preparation of the project. The demand for an energy efficient renovation was first expressed by tenants who did not agree with a proposal for demolition and new construction and a very low profile renovation.
Aramis AlleeWonen developed the energy renovation programme, and hired Nederlandse Woonbond, a national tenant representative organization, to support the tenants and ensure that proposals were beneficial to the tenants. Similar to other renovation schemes a 70% agreement among tenants was needed to implement a renovation scheme in all houses of a project. In order to convince the tenants, the projected energy savings have been guaranteed to the tenants by Aramis AlleeWonen. The involved stakeholders are provided in the table below:
<table>
<tr><th>Role</th><th>Name</th><th>Brief</th><th>Design</th><th>Construction</th><th>Monitoring</th></tr>
<tr><td>Building owner</td><td>AlleeWonen</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>Architect</td><td>DAT architecten</td><td></td><td>X</td><td></td><td></td></tr>
<tr><td>Energy Specialist</td><td>Trecodome</td><td></td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>Structural engineer</td><td>VDM Woningen bv</td><td></td><td>X</td><td></td><td></td></tr>
<tr><td>HVAC engineer</td><td>Dubourgraaft</td><td></td><td>X</td><td>X</td><td></td></tr>
<tr><td>Contractors</td><td>VDM Woningen bv, Van Ieperen bv, Brink Climate systems</td><td></td><td></td><td>X</td><td></td></tr>
<tr><td>University</td><td>TU Eindhoven</td><td></td><td>X</td><td></td><td>X</td></tr>
<tr><td>Other</td><td>Nederlandse Woonbond</td><td></td><td>X</td><td></td><td></td></tr>
</table>
</td>
<td>True</td>
</tr>
<tr>
<td>WHEN</td>
<td>The renovation intervention began in 2010 and finished at the beginning of 2011.</td>
<td>Timing respected.</td>
</tr>
<tr>
<td>WHY</td>
<td>The investment cost for the intervention was 1.107€/m², making a total of 509.220 €. According to the provided data, the yearly cost savings for energy result in 4.622 € for monitored values. The payback period according to the data provided and SCIS calculations exceeds 30 years. A rent increase of € 65,00 was agreed, which was on average to be assumed to cover the anticipated savings.
The financial analysis shows that the profitability of the project is not given due to the high investments in comparison to the low energy cost savings. This however does not reflect non-monetary benefits that might occur during implementation. The life time of the buildings is extended with 50 years, without the need for investing in new buildings and replacing tenants.</td>
<td>Missed achievement of profitability has been balanced by non-monetary benefits</td>
</tr>
<tr>
<td colspan="3">Key features:
One key aspect was related to the continuous involvement of tenants. The renovation in the Roosendaal pilot buildings took place with the tenants remaining in their homes throughout the work. This required both a fast and non-intrusive renovation process and a continuous dialogue between the housing company and the tenants.</td>
</tr>
</table>

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The BC showed that the replication potential was large, provided that further industrialization, product development and implementation scale result in affordable investment costs. Findings from this BC have already motivated suppliers from industry to launch products along these lines. A regulatory drawback concerned the Dutch market and in particular the scale of the national energy-labelling scheme. In The Netherlands much less energy efficient schemes than demonstrated here are entitled to be A or B-rated. Real energy efficient renovations are not encouraged because of the chosen calculation method behind in which it is not possible to calculate and to value a passive house renovation scheme. Real energy performance figures though indicate that much better energy performance levels than referred to in the Dutch A and B rating are needed to achieve affordable heating bills and desired CO_2 emission levels.

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Dieselweg Residential apartment block, Graz, Austria

Images (PRE/POST)		
Energy performance (PRE/POST)	The original energy consumption was 184 kWh/m^2.	The energy consumption after retrofitting is 12 kWh/m^2 y.
Business Case: W13	**Comparison to BM**	**Note on compliancy with BM towards achievement of target**
WHO	The BC is a residential apartment block, consisting of 16 apartments, built in 1959 and renovated in 2008-2009 for a total floor area of 1589 m^2. The passive house standard was achieved and the heating costs significantly decreased. CO_2 emissions were also reduced by the use of renewable energy sources, e.g. solar thermal energy. Prefabricated large-scale façade modules with integrated windows and ventilation systems were used. In this way, an essential increase of the thermal and user comfort was achieved and the indoor environment was improved.	Large residential buildings, with public owner
WHAT	The renovation process has been performed through the addition of volume to the building being it a façade addition. The renovation used industrialised construction methods and prefabricated elements in order to shorten project time and reduce the impact for tenants. The added volume and dwelling area consist of a bonus, a complementary economic instrument for the investors (real estate investors, construction companies in conjunction with ESCO, etc.) also considering the possibility of creating a risk fund with the real estate surplus generated by the new building, which could cover the risk of arrearage for the inhabitants in paying the bills.	Complete value proposition satisfied
HOW	The renovation is developed and managed by a synergic work involving a group of experienced architects and design planners working on the subject of deep renovation with a particular attention to building quality and architecture regeneration. A constant involvement of final users is fundamental to correctly target their needs and provide functional and demand-responding solutions. The involved stakeholders are provided below: • Owner: GIWOG Gemeinnützige Industrie Wohnungs AG • General planer: gap-solution GmbH • Architect: Architekturbüro Hohensinn ZT GmbH	True

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	• Energy concept: ESA - Energie Systeme Aschauer GmbH • Report: AEE INTEC	
WHEN	The renovation of the buildings, performed in the framework of the SQUARE project (see Appendix 1), started in 2008 and fwas completed in 2009.	Timing respected.
WHY	The total cost of renovation was equal to 8,8 M€ (excluding VAT). Supported by the Austrian system of public housing subsidies and additional help by research funds and a special support provided by the Governor of Environmental Affairs of Styria, Manfred Wegscheider, in connection with the nonprofit status of GIWOG, a fit solution was found in order to keep up the social low rental fees combined with a amortization of investments within reasonable time. In particular: • € 7.3 Mio funding by GIWOG Gemeinnützige Industriewohnungs AG (including subsidies from the Styrian Government) • € 1.0 Mio. funding by Federal Government of Austria • € 0.5 Mio. funding by Styrian Government, Department of Environmental Affairs	Financed by third parties and research funds

Key features:

The most challenging circumstance of this project was related to tenats resettle that was impossible during constructions works. A perfect financial solution had to be provided in order to convince the inhabitants to accept all the interference and disturbances. Supported by the Austrian system of public housing aid, by additional research funds and by special support provided by the governor of environmental affairs of Styria and the nonprofit organisation “Wohnungsgemeinnützigkeit” of the GIWOG Corporation a solution has been found, that kept the social rental fees low and allows an amortization of the investments within reasonable time.

From the technical point of view the following advantages of the renovation concepts may be undelined:

- Energy performance=passive house standards
- Improvement of indoor and outdoor living quality
- Smart and quick on-site construction procedure
- Occupants are less disturbed during construction phase
- The existing static system stays unaffected
- Thermal bridges are eliminated
- High quality due to prefabrication in fabrication hall
- Weather-indipendent fabrication
- Separable and particularly reusable components

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1.1.1.10. Common Factors and main recommendations

In all the four BCs, the following common aspects have been noted:

- **Importance of tenants engagement and countinuos communication**. The involvement of tenats during the entire renovation process represented a key aspect to consider, in order to permit larger acceptance in the light of the living standard improvements targeted;
- **Funding:** Usually the involvement of a capital provider is required (financial institutions, developers, managers, householders, policy-makers, buildings owners and associations) to finance a large-scale renovation project.
- **High replication potential** is related to this BM, especially in Western Europe.

The analysis of application of Add-on Business Model provides potential recommendations/best practices for the whole process of refurbishment. The preliminary conclusions and recommendations are listed below according tot he following categories of refurbishment process.

<table>
<tr><td></td><td>Stakeholders evaluation</td></tr>
<tr><td colspan="2">The renovation work has to be developed and managed by a synergic work involving a group of experienced architects and design planners working on the subject of deep renovation with a particular attention to building quality and architecture regeneration.
Another aspect that has to be taken into account is related to the importance of involving tenants since the beginning of the project, allowing them to take part in decision making processes and influencing decisions about renovation measures, constraints evaluation and possible solutions. A better link beetween owners and tenants shall allow both of them being more aware of each others perspectives and organisational and financial limitations. This approach should help in breaking down misunderstandings, helping to remove any mistrust between landlord and tenants, and building mutual respect and understanding.</td></tr>
<tr><td></td><td>Project development and planning</td></tr>
<tr><td colspan="2">The possibility to install RES technologies in parallel with volume addition may represent a key point to evaluate during renovation planning. When combined with the adoption of EE or RET measures, volume additions are interesting type of intervention since they instantly produce new, commercially valuable dwelling area which could compensate the costs of energy-optimisation. In this way the building renovation process should be attractive to financial actors and decision-makers (financial institutions, developers, managers, householders, policy-makers, buildings owners and associations) and also have important environmental and social impacts.</td></tr>
<tr><td></td><td>Implementations</td></tr>
<tr><td colspan="2">From the technical point of view it has been desumed that innovative technologies shall rely on awareness of all actors involved that truly sustainable architecture in the renewal of existing building stock cannot be achieved by using standard methods, standard processes or a standard amount of time and money. For this reason, a fundamental change in awareness of stakeholders involved, supported by a strong quality of communication, plays a vital role in accomplishing the desired standards in the future.
Together, the owners, tenants and planning partners had to improve in:
• arranging and developing innovative methods and details with partner companies and craftsmen;
• measurement sequences in complex conversion processes;
• finding ways to establish new regulations in order to get the right partners, not only with regards to competence but also professionalism.</td></tr>
</table>

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<table>
<tr><td colspan="2">A fundamental change in human awareness and the quality of communication shall play a vital role in accomplishing the desired standards in the future. Truly sustainable architecture in the renewal of existing building stock cannot be achieved by using standard methods, standard processes or a standard amount of time and money.</td></tr>
<tr><td></td><td>Documentation and monitoring</td></tr>
<tr><td colspan="2">In respect to monitoring, the system used has to be simple because too sophisticated tools can bring to unwanted drawbacks related to data management and user perception.</td></tr>
</table>

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4. Main Conclusions

This report has been prepared in the framework of WP5 “Promotion of new business models and validation through business cases” of STUNNING project “SusTainable bUsiNess models for the deep renovation of buIldiNGs” (GA: 768287). The document reports about activities carried out within the course of Task 5.2 “Application of new business models and validation through business cases”.

This task aimed to test innovative Business Models identified in the project within at least 10 business cases, namely success retrofitting intervention on buildings having lower energetic efficiency and providing the most interesting features for the implementation and achievement of business targets.

Indeed, for the most promising Business Models selected within the project, the availability of the related application in real environment has been investigated. When available, it was not always possible to access the information on the related BCs, mainly for confidentiality issues. As a whole 14 BC have been gathered.

The focus of this report was the analysis of these 14 BCs, performed at three different levels:

- At **geographical level**, to evaluate the external boundary conditions influencing the BM application as well as the geographical coverage of the BC identified to prepare the ground for replication
- At **building level**, to identify the internal boundary conditions, namely the building features as well as the typology of building ownership.
- At **Business Model level**, to analyze in details the application of the identified BM to the real case study and evidence each aspect (from the channels used from the technology providers to the market, as well as actions due, how they should be executed and who should be involved, etc.). In addition to that, key features (key element that had a relevant role on the BM success) and common success factors of each BCs (in case of more than 1 BC it may be relevant to evaluate common procedures or synergies) have been evaluated. Finally, the overall scope of these analysis was to evaluate compliancy with the BM and based on that to highlight general lesson learned from specifi BM application at BC, comprehensive of the typical needs of the refurbishment activities.

Leveraging on this, the main outputs of the analysis have been summed up per BM category.

One-Stop-Shop model based on PPP

Concerning the One-Stop-Shop model based on PPP, the outcome from the identified BCs analysis shows that the organisation of the retrofitting process itself is key to a successful energy retrofitting. Information and leadership is very important, including the planning and coordination of works and the ambitions of contractors on site. Since some stakeholders may be leaving the project during its life-time, it is recommended to maintain the engagement, and the information and involvement of new members is crucial to the organisation.

All performers and key actors of the process need to be involved. For this reason, kick-off meetings in the start of a construction project involving everyone engaged in the project and with an impact on the result, can be the first step of the process. The kick-off gives the building owners an opportunity to explain their view on and targets for the project. Consultants present their designs and more important their core ideas, and contractors and other partners can give their views on the systems. The main task

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of the kick-off is then to align the teams and for everyone to agree on common goals for the process, to share the view and ideas on methodology and theory.
Another involvement parameter shown to be very important in the retrofitting process is the personal competence and engagement of building owners, designers and contractors. Building owners and social housing companies with a dedicated person engaged in sustainability issues seem to have a great advantage and a great driving force for a successful process.
The extensive renovation and sharp energy focus mean that future financial risks are reduced, as operation and maintenance costs will be significantly lower following the retrofit. There is also a transaction of future behaviour-related risks of energy costs from the building owner to the tenant, as the tenants take charge of their own energy bills and possible savings after the renovations (before, the costs were included in the rent, which did not encourage energy saving). The improvement of quality in the buildings and the status of the neighbourhood will also minimise future financial risks such as vacancies.
Beginning with the energy consumption in practice and making plans based on user behavior is accepted as a major innovation in renovation, in order to achieve targets.

One-Stop-Shop model based on Step-by-Step Approach

Key aspects were mainly two, respectively related to RP and project monitoring. Central role of the Refurbishment Package in the retrofitting process makes that it is fundamental to assure quality of building components and monitor their status in order to replace them according to their real life span. Products certification is a must. Moreover, In order to ensure a successful delivery of Step-by Step BM, it is also suggested to include the deployment of "minimal monitoring" solutions within refurbishment. Indeed, by validating the amount of energy saved through the completed partial modernisations in the same way as after a complete overall refurbishment, may help in the building energy savings target achievement.

One-Stop-Shop model provided by multidisciplinary team cooperation

Concerning the One-Stop-Shop model provided by multidisciplinary team cooperation, Energiesprong model has been able to move project forward relatively smoothly, running well within the government's existing administrative and financial standards. However, some challenges have been noted specifically around the size and impact of such projects on organisational resources. It is therefore essential that the local project coordinator acts as a channel between colleagues and the project to support, 'translate' and motivate engagement. It is also essential that the coordinator has the time and resources available to be able to provide this service alongside the overall procedural management of the project. Key skills to support this role include academic understanding, project management experience and a thorough understanding of the organisational structure.
A growing demand for Energiesprong retrofits will produce a market response that brings down costs and increases quality. Component suppliers are expected to compete by offering longer guarantees to secure these larger orders. This will help ensure they offer only reliable, high quality components.
In many countries, social housing tenants cannot yet fully profit from self-consumption and renewable energy production. Thus, law must be changed to introduce an Energiesprong energy bill policy similar to the Netherlands.

Energy Performance Contracting

Concerning EPC, recommendations for implementation include: a well-structured homeowner organisation (social and legal experts); a balanced set of energy saving measures and a corresponding financial scheme (technical and financial experts); a clear long-term view of the real estate and its

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neighbourhood (social and real estate experts); cost-effective packages of energy-saving measures; model contracts within the valid legal and financial constraints; interest from commercial ESCOs for further implementation. Implementing EPCs also requires to select large builsings or cluster buildings to reach a “critical mass”, as EPCs are only suitable for large projects with a minimum energy cost baseline of 200k€/year.

In addition to that, it is also suggested to develop a solid methodology to calculate a reliable relation between energy saving measures and the prediction of total energy consumption in order to overcome the barrier related to the uncertainty (and the complexicity of measurement) of the real energy savings and therefore alleviate the uncertainty of allocation of the energy savings.

Add-On Business Model

Within the BM, the possibility to install RES technologies in parallel with volume addition may represent a key point to evaluate during renovation planning. When combined with the adoption of EE or RET measures, volume additions are interesting type of intervention since they instantly produce new, commercially valuable dwelling area which could compensate the costs of energy-optimisation. In this way the building renovation process should be attractive to financial actors and decision-makers (financial institutions, developers, managers, householders, policy-makers, buildings owners and associations) and also have important environmental and social impacts.

Common key features to most of the BM were the following:

- Strong tenants engagement. In particular it is suggested to adopt a multi-level approach for buildings’ owners involvement. Meetings’ schedule based on the bottom-up approach and on private meetings with each occupant is suggested, at least in first level, in order to explain all parameters related to the renovation project but also of the general legislative framework that govern the overall project’s subject. Contacting directly and organizing the occupants concluded to be the best approach.
- Economic incentives from EU, local government or loan. Usually the involvement of a capital provider is required (financial institutions, developers, managers, householders, policy-makers, buildings owners and associations) to finance a large-scale renovation project.
- Strong attention to energy monitoring before and after retrofitting. Potential new methodology shall arise.

Mainly for the district renovation, such as Laguna de Duero, but also for the other BC, the most important lesson learnt regarding financial and economic issues is that the contribution of the EC grant has been an essential part of the funding, without which several business cases would not have been feasible in the same conditions, due to the high investment costs that such a number of dwellings entail.

Finally, ultimate goal of this report is to build upon above described lesson learnt from the business cases to make renovation more profitable and bring the renovation rate up to 3% by 2020. This replication potential will be thus investigated in D5.3 “Report on replicability potential”, relying also on the analysis of market mechanisms and barriers evaluation towards wider BM application performed in D4.1.

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5. Appendixes

5.1. Appendix 1: Business Case template

Name

Description

Small description

Involved stakeholders

Location

Environmental data

Information on local constraints / regulations / incentives

Building characteristics

Performance before

Performance after

Refurbishment package

Business model

Lessons learnt and guidelines for replication

Pictures

Useful links

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5.2. Appendix 2: Most promising BM

5.2.1. BETTERHOME

BetterHome

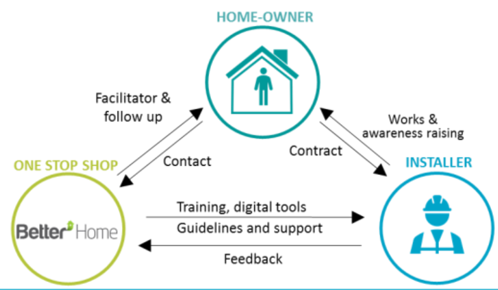
- **Digitally enabled OSS**

Problem addressed:
Energy refurbishment considered as too **complex** by home owners

The solution:
Home-owner centric renovation journey:
Transparent and reliable process
Value for money
Digitalisation-driven: web platform, digital toolbox

Target:
Single family houses, Denmark

How:
4 funding companies (Danfoss, Grundfos, Rockwool, Rockfon), cooperation with banks, network of installers



Achievements:
High conversion rate (from leads to order: >10%)
Turnover in all lead channels: **EUR 66,7 mill 2015-2018 (1182 projects)**
Avg. project size: **EUR 50.000-60.000**

5.2.2. ENERPHIT

EnerPHit

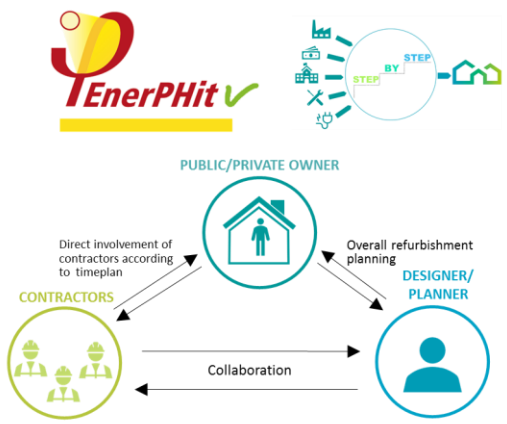
- **OSS based on Step-by-step approach**

Problem addressed:
Building components renewed unnecessarily before time

The solution:
Repair/replacement of components according to their life duration
Overall plan for all measures including the ones in distant future
Initial investment is taken advantage of to its fullest
Investment spread over a long period of time
Retrofit performed according to necessity

Target:
Residential housing (single family or multi-family) but also public buildings or offices. Country: IT, IE, UK, FR, SP, DK, BG

How:
The designer (planner) is in charge of the whole renovation plan including different steps to be carried-out and the time schedule. The owner maintain a central role.



Achievements:
About 20 pilot case studies developed within the Europhit Project

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5.2.3. EPC

EPC

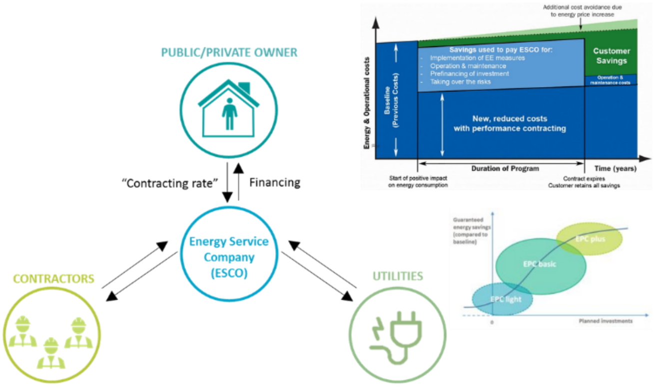
- **Energy Performance Contracting**

Problem addressed:
High risk and complexity for home owners for the selection of technical solutions to adopt

The solution:
Risk assumed entirely by the ESCO financing the renovation
The contracting rate needs to cover all expenses of the ESCO for the defined scope of services throughout the contractual period
"Contracting rate" calculated as a percentage of the savings achieved through the EE and RE measures.

Target:
Public institutions buildings (universities, hospitals and leisure facilities) – Big project size (energy cost 100k €/y).

How:
The ESCO is responsible for the implementation and operation of the energy package at its own expenses and risk, according to the project-specific requirements set by the client.



Achievements:
The combination of both structural renovation (EE) and energetic optimization (RET) leads to high energy savings up to 50%.

5.2.4. EUROPACE

EuroPACE

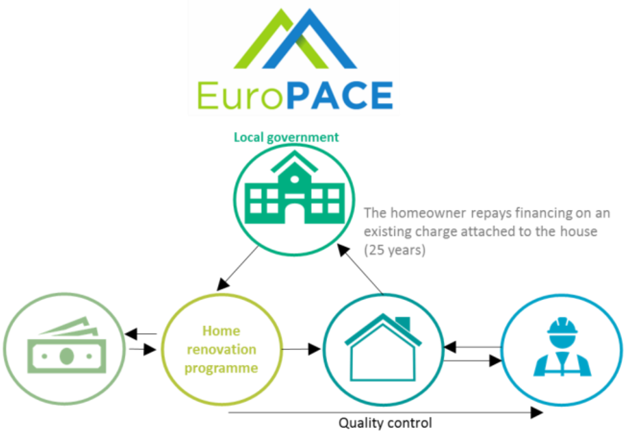
- **OSS with innovative financing**

Problem addressed:
Energy refurbishment considered as **too complex and costly** by home owners

The solution:
Simple, affordable & reliable home renovation for all
Home-based financing (attached to the property)
Technical support
Home improvement packages: family wellbeing
Quality control

Target:
Single family houses, apartments. Country: depending on market readiness

How:
EU project, with involvement of local authorities, a network of trained and qualified energy contractors. Partnership with banks.



Achievements:
First pilots in 2019
Based on the successful **PACE Nation** from the US

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5.2.5. ENERGIESPRONG

EnergieSprong

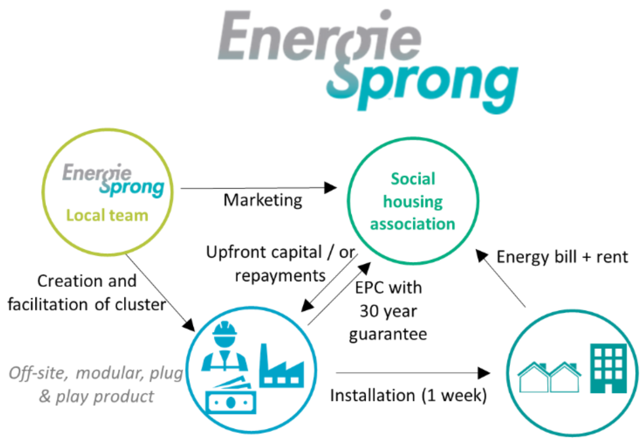
- **OSS with cooperation cluster**

Problem addressed:
Energy refurbishment considered as **too complex and costly** by home owners

The solution:
Desirable, warm, affordable homes for life
Net zero energy consumption warrantied over 30yrs
Attractive, comfortable (new kitchen, bathroom)
Investment financed at 100% by energy savings (30 yrs)
Retrofit performed in 1 week maximum

Target:
Social housing (terraced houses mostly, now also multi-apartments). Country: NL, UK, FR, DE

How:
Cooperation cluster (solution providers, market development team, contractors and SMEs). Partnership with social housing companies.



Achievements:
Close to **10 000 renovations NZE certified**
Objective: mass market by 2020, **target price 65k€**

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5.3. Appendix 3: References - EU projects

Reference documents for the above-described BC analysis have been data from EU projects having the BC as pilot demonstrators" of the related business models. The following table provides an overview of the mentioned EU projects main information.

Project	Acronym	Status	Website	Short description
Building Energy Efficiency for Massive market UPtake	BEEM UP	Closed	http://www.buildup.eu/en/node/55224	BEEM-UP was a Public Private Partnership collaborative project that aimed to demonstrate the economic, social and technical feasibility of retrofitting initiatives for drastically reducing the energy demand in existing residential buildings, and lay the ground for massive market uptake of such initiatives.
Retrofitting for the energy revolution, one step at a time	EUROPHIT	Closed	https://europhit.eu/	With the EnerPHit Standard as the goal and Passive House principles as the basis, EuroPHit applied knowledge on deep energy retrofits to the oft-overlooked yet critical area of step-by-step refurbishments
Industrialised Energy Efficient Retrofitting of Resident Buildings in Cold Climates	E2REBUILD	Closed	http://www.e2rebuild.eu/	E2ReBuild project investigated, promoted, and demonstrated cost-effective and advanced energy-efficient retrofit strategies that create added value for existing residential buildings and endorse end-users to stay and build a dynamic society. The vision of E2ReBuild was to transform the retrofitting construction sector into an innovative, high-tech, energy efficient industrialized sector.
Replicable and innovative future efficient districts and cities	CityFIED	Closed	http://www.cityfied.eu/the-cityfied-project/about.kl	CITyFiED is a project based on a mix of demonstration, renewable energy technologies and sound business models towards the sustainable development of cities. CITyFiED aims to enhance the energy efficiency of the city districts and provide a high quality of life to its inhabitants through a better management of its resources.
Energy Exploitation and Performance Contracting for Low Income and	ECOLISH	Closed	http://www.ecolish.com	ECOLISH was a project that aimed at overcoming barriers to promote energy efficiency in low income and social housing by organising and evaluating pilot projects using Energy Performance Contracting (EPC) and Energy Exploitation in

Social Housing (ECOLISH)				four European countries (i.e. Netherlands, Latvia, Greece and Hungary).
Desirable, warm, affordable homes for life	E=0	On going	http://www.nweurope.eu/projects/project-search/e-0-desirable-warm-affordable-homes-for-life/	E=0 will support the development of home makeovers to net zero energy levels in FR, NL, UK and LUX. E=0 will address poor energy performance of residential buildings by generating a new mass market for net zero energy retrofits across NWE.
Regeneration model for smart urban transformation	Remourban	Closed	http://www.remourban.eu/	REMOURBAN is a lighthouse project whose ultimate goal is to design and validate a urban regeneration model in the cities of Nottingham (UK), Valladolid (Spain) and Tepebasi/Eskisehir (Turkey), while maximizing its replication potential in two follower cities, Seraing (Belgium) and Miskolc (Hungary).
A System for Quality Assurance when Retrofitting Existing Buildings to Energy Efficient Buildings	SQUARE	Closed	http://www.iee-square.eu/	The SQUARE project aimed to assure energy efficient retrofitting of social housing with good indoor environment, in a systematic and controlled way. To achieve this, a quality assurance (QA) system for retrofitting and maintenance was adopted in pilot projects in several European countries.