Building Energy Efficiency for Massive market Uptake

Full retrofitting process documentation of each site

BEEM-UP

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BEEM-UP

Building Energy Efficiency for Massive market UPtake

Integrated Project

EeB-ENERGY-2010.8.1-2
Demonstration of Energy Efficiency through Retrofitting of Buildings

Deliverable D.2.7: Full retrofitting process documentation of each site
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Dissemination Level		
PU	Public	**X**
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Deliverable description

The retrofitting of the three BEEM-UP pilot projects aims to demonstrate how high ambitions in energy efficiency – aiming at a 75% decrease in energy demand for space heating – can be met and how the retrofitting process of three representative European multi-family dwelling areas was conducted. The deliverable D2.7 gives an executive summary of the processes in all three sites, including key messages and lessons learnt.

This deliverable presents the retrofitting processes in all three BEEM-UP pilot sites, located in the cities of Paris/France; Alingsås/Sweden and Delft/the Netherlands (see Figure 1). The report gives an overview of the background conditions, key experiences and lessons learnt in all three projects, compiling the stories from the building owners (ICF Novédis; Alingsåshem and Woonbron respectively) and the continuous progress documentation of each site.

To support replication of the BEEM-UP processes, it has been found wise to well describe the pilots and the prerequisites of each project (as to the buildings, national regulations and other local conditions or traditions) to let the potential followers identify what measures and experiences that can apply to their own projects and conditions. Since the EPBD targets apply to all EU countries plus Norway, a reduction of energy use is of interest to building owners all across Europe. The three demonstration pilots do together also show a much wider representation on a European level than a single example could do.

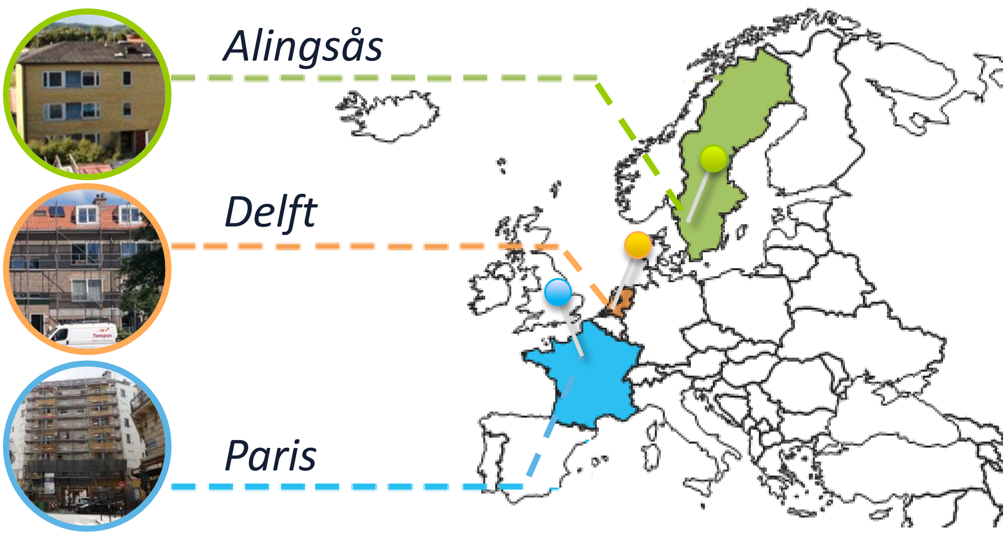

Figure 1 Situation of the three BEEM-UP retrofitting pilots in Sweden, the Netherlands and France

By tailoring general principles to regional frame conditions we have achieved high local acceptance and delivered three outstanding examples with a good variety. This variety is also the key asset when it comes to upscaling, as we now have three different approaches from which oncoming followers can choose whatever fits their situation best in terms of technical, economic and organisational prerequisites. The holistic approach, focusing on achieving good dwellings socially, economically and ecologically, can be replicated as an overall goal of any retrofitting process.

Chapter 1 describes the three pilot sites, their national and technical preconditions and selected measures per site, to serve as a background description. To sum up the overview, illustrating that high energy efficiency is possible to achieve through retrofitting, the monitoring results in actual energy use reduction per site are presented. Chapter 2 patterns the retrofitting processes and lessons learnt of each site, from the building owners' point of view. Finally, the continuous documentation of the retrofitting process itself in all three sites is attached.

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Chapter 1 Background: demonstrators and prerequisites

This chapter makes a brief presentation of the three pilot sites and their prerequisites for energy efficient retrofitting respectively, to better explain their representation. Future followers can relate to the conditions of their own project to identify what measures that can be applicable for replication in their process or building.

1.1 Overview of the three demonstrators

The three BEEM-UP demonstration projects represent three different building types, all common in Western Europe. They are closer described in Table 1 below.

Table 1 Description of the three demonstration projects of BEEM-UP (information from building owners)

		
Paris, France: One 8-storey multifamily building by a city street corner Built in 1959 87 flats; 3,369,000 alike in FR * Situated in an urban city area close to the Gare Montparnasse railway station. *) Estimations by ICF Novédis and the TACKOBOST project	***Alingsås, Sweden***: Eight 2-4 stories multifamily buildings grouped around courts Built in 1971-73 144 flats; 400,000 alike in SE ** Arranged around large car free courts in a green environment on walking distance from the town. **) Estimations for Brogården by Hans Eek, Architect MSA/SAR	***Delft, the Netherlands***: Eight 2-4 stories terraced houses with small backside gardens Built in the 1950's 108 flats; 650,000 alike in NL *** Situated along five more quiet streets outside central Delft. ***) Estimations from Woonbron

As shown in Table 1, the demonstration buildings are chosen to be representative to a great number of dwellings around the EU. Considering the estimations of BEEM-UP, there is altogether close to 4.5 million dwellings alike in the three countries alone. Areas like the ones in Delft or Alingsås can be found in several suburbs and smaller towns while the Paris building is part of a typical city quarter. Although both the previous buildings have brick façades, the Delft buildings are entirely erected in masonry while the Alingsås ones have a casted concrete structure. The Paris building was built by sandwich wall elements rendered on site. The urban location in a city quarter of a large European capital also calls for a different approach than for the rather quiet areas in Alingsås and Delft.

1.2 Ownership and legal/economic conditions of the building owners

The table below gives a background to the building owners of the three demonstrations and their work.

Table 2 Description of the three BEEM-UP building owners and their working conditions

	Paris, France:	***Alingsås, Sweden:***	***Delft, the Netherlands:***
Company	ICF Novédis - a subsidiary of ICF group, with 100,000 dwellings, which belongs to the French railway company SNCF. ICF Novédis manages 16,000 dwellings targeted at railway employees.	AB Alingsåshem is the public housing corporation of the municipality of Alingsås, Sweden. AB Alingsåshem owns 3,300 dwellings and builds approximately 50 new dwellings every year.	Woonbron is one of the largest social housing companies in the Netherlands (top 5). Woonbron serves a 40,000 households and has five offices in Rotterdam, Spijkenisse, Delft and Dordrecht.
Directives/Mission	80% of all the dwellings in ICF group are social housing, where as much as 30% of all are occupied by railway employees. ICF Novédis has no social housing ICF´s policy is to build at low-energy standard for all individual housing.	To provide dwellings for everyone and to fulfil the sustainability targets of Alingsås. To ensure a good heterogeneity among the tenants, Alingsåshem uses a tenant typology to form their offers to tenants.	Non-profit entity with a legal task to provide housing to low-income target groups. Not only to build, maintain, sell and rent housing but also to provide other services related to use of dwellings.
Tenants and client relations	Railway employees can rent an ICF flat at a lower price, as a part of their work contract with SNCF. Dwellings can exceptionally be sold to sitting tenants, but the housing company makes the decision. As a 2009 law allows, half of the savings generated through energy efficiency measures, once clearly evaluated, can be billed to the tenants as common charges. Rents subsidies from the state are available for the poorest in any apartment.	Housing open for all. Rents are negotiated with the union of tenants. Rent increases need to be motivated by e.g. an improved standard of living. Energy efficiency measures do not motivate a rent increase. Tenant typology for varying and adopted offers. Municipalities can decide to sell dwellings.	Tenant households with a yearly income below €34,000 for a rental flat. Priority for people with relatively low income. For people with the lowest income, up to a 50% rent subsidy can be obtained from national regulations. A 30% discount is made for sold out flats to attract groups with a lower income, with the obligation to offer the flat to Woonbron for re-possession if moving. Annual rent increase is related to income of tenant. In complexes rent-increase can be made mandatory if 70% of the tenants agree on the measures proposed.
Ownership structure	Tenants own their own white goods.	Shared laundry facilities. Kitchen white goods in flats is owned by the building owner.	Tenants sometimes own their own heating and heat distribution systems, more often they rent it. White goods and floor carpeting are tenant owned.
Consumption billing, before	The building owner pays heating, water and common electricity. Individual household electricity is directly billed to the tenants.	The building owner pays central heating, common electricity and domestic hot water (DHW).	Tenants pay their own gas and electricity consumption, which are both individually metered.

1.3 National and local requirements

1.3.1 Energy requirements

Some different requirements apply nationally or locally to a retrofitting project, such as the energy requirements in national building codes;

- **In France**, the Thermal Regulation for existing buildings applies, aiming to reduce the primary energy demand for heating, cooling and domestic hot water (DHW) for residential buildings. Currently, the average consumption for these is around 240 kWh/m²·yr. Since 2010, the demand has to be reduced to between 80 and 165 kWh/m²·yr, depending on the climate context and the type of the heating source. Theoretical Energy labelling A++ - G also apply.

- **In the Netherlands**, the Energy section of the Building Decree only applies to new buildings, where an Energy Performance Coefficient (EPC) is set to nationally define a Zero Energy Building (ZEB) target for the EPBD 2020 goals. EPC involves space heating, DHW and common electricity except common lighting for dwellings. For existing buildings, an Energy Index EI can be voluntarily calculated to express energy savings in similarity to the EPC. Theoretical Energy labelling A++ - G is also used. All Dutch housing associations have pledged to strive for an average B-label by 2020 with regards to their stock.

- **In Sweden**, building code BBR manages the EPBD targets for new and existing buildings. For the version BBR19 [1] the energy demand (not electrically heated) for Alingsås is limited to 90 kWh/m²·yr for space heating, DHW and common electricity. For Swedish passive houses, definitions FEBY 2007-2012 apply [2]. Currently, the corresponding figure for new passive houses is 50 kWh/m²·yr and the maximum heat power demand 15 W/m². Air tightness is set to 0.30 l/s·m² q_{50}. For retrofitting there are no specific FEBY requirements yet.

Focusing on the national EPBD goals presented above, it is clear that actions are primarily needed to reduce energy demand for space heating, DHW and common electricity in these three countries. Space heating is also the overall highest share of domestic use of energy in EU as a whole, with an EU average of 67-68% [3, pp. 20-21]. Although the BEEM-UP pilot countries are mainly representative for Nordic and Central European climates, even in countries where the total energy demand is significantly lower, space heating can be subject to interest as it mostly holds a 60-80% share of the end-use demand per dwelling according to the Odyssee-Mure project. The only EU exceptions shown to deviate from in these measurements are Cyprus, Spain, Portugal and Romania (p21).

Improvements of the building envelopes can be used to reduce energy losses due to transmission or air leakage, which also improves the thermal comfort and moisture content of buildings when thermal bridges, poor insulation and cold draughts are addressed. Furthermore, renewable energy is of interest, as well as the reduction of heating energy demand through heat recovery and upgraded equipment, in order to reduce climate impact and the dependence on fossil energy carriers.

The retrofitting targets a 75% decrease in the *energy demand* for space heating. However, the real-life result might deviate from the building's theoretical demand due to tenants' behaviour. In section 1.6, the early measurements of resulting *energy use* after retrofit, including behaviour-related aspects, are presented. The monitoring results and energy performance of the buildings before/after retrofit are thoroughly analysed in the *D3.8 BEEM-UP Final reporting of monitoring results in all three sites* (public report) [4].

1.3.2 Other requirements

Additional technical requirements or boundary conditions also apply to specific projects, such as

- National building codes/other requirements as to indoor climate or cultural preservation
- National building traditions and nationally accepted methods for e.g. supplementary insulation
- Common building services systems on the national market, traditions, behaviour

A few examples of more qualitatively expressed requirements from the BEEM-UP pilots;

- Architecture: The French pilot is situated in an area of historical importance which limits what exterior measures that are allowed by the community. In Sweden, the architectural expression of the area as a whole is to be kept and developed in a dialogue with local authorities.
- Regarding national building traditions, Dutch tenants normally expect natural ventilation. As Swedish construction methods historically often involves timbering, common central European insulation methods as EIFS/ETICS are considered risky nationally since severe moisture damage have occurred to timber frames after water penetration through the mortar and insulation layers. The Swedish building code also states that relative humidity RH in building materials must never exceed 75% due to mould risk.

1.4 The existing buildings and their technical state

As a starting point, the pilot buildings' existing state as to building envelopes and building services are described in this section, to further pattern their representativity to other projects. The replication potential of specific measures implemented within BEEM-UP is higher to projects with similar systems, problems or qualities; therefore an overview of these conditions is needed.

1.4.1 Existing qualities and defects

The challenge in retrofitting the areas is, as expressed by the Swedish building owner, to address the defects of the buildings while keeping their soul and enhancing the qualities that make them popular homes today. One of the main strengths of the BEEM-UP project is that the analysis and selection of measures are made from the needs of the end user, rather than the implementation of energy efficiency being forced from a top down perspective.

To enable comparison, qualities and defects assessed for each demonstrator are presented in Table 3 below. Improvement of energy efficiency is of overall importance in all three sites.

Table 3 Existing qualities and defects/specific measures needed (apart from improved energy efficiency) Source of information BEEM-UP WP1.

	Paris, France:	***Alingsås, Sweden:***	***Delft, the Netherlands:***
Existing qualities	Popular central city location Close to services and public transportation, in particular the Montparnasse railway station All flats have a small balcony or a large roof terrace with a view Existing backyard, now only used for storage	Architecturally valuable buildings and coherent area Quiet area close to town centre and nature. Green, car free courts with playgrounds. All flats have a balcony or a patio District heating network with 98% renewable fuel (mainly wood waste from the forest industry, additionally biogas from waste)	Specific identity and quality Quiet area close to town centre with small scale buildings Traditional architectural expression of buildings and brick façades. Popular gardens
Existing defects	Façades, roof, windows need renovation and insulation Electricity, plumbing and HVAC systems in poor state. New boiler needed No individual heat control, bottom flats too hot. Thermal bridging, risk of condensation/mould, poor sound proofing. Draughty windows. Bathrooms, kitchens, staircases need renewal	Frost wedged façades need replacement, poor insulation Electricity and plumbing systems in poor state, high use of DHW Discomfort due to draughty flats, thermal bridging and poor sound proofing. Poor accessibility and little variation in flat sizes Bathrooms, kitchens, common areas need renewal	Façades need maintenance. Poor roof insulation and windows Large variation in heating systems and distribution among flats, several flats need new boilers Risk of thermal discomfort or moisture problems due to poor insulation of roofs and bottom floors. Draughty windows

1.4.2 Original building systems

What measures for retrofitting that can be technically appropriate relates to the existing systems and their status. The following Table 4 provide an overview of the original structures, building envelope and installation systems of the pilots (illustrated in Figure 2 and Figure 3) to correlate to the selection of measures in the next section.

Table 4 Technical systems on building level for the three demonstration projects before retrofit.

	Paris, France	***Alingsås, Sweden***	***Delft, the Netherlands***
Structures	Concrete structures, load bearing exterior sandwich walls and flat concrete roofs	Load bearing concrete structures, wooden studs infill walls, cold attics with a wooden exterior roof.	Load bearing cavity brick walls with suspended wooden floors and pitched wooden roofs
Building envelope (see Figure 2)	Rendered façades, thin insulation towards the street, supplementary EIFS towards the backyard. Roofs covered with gravel. Basement not insulated	Curtain brick façades changed once, but in poor state. Windows changed in 1980's. Bitumen roof covering. Thin insulation (mineral wool board) under floor slabs.	Exterior side of walls function as brick façades. Supplementary insulated cavities. Tiled roofs, not insulated. Basement crawl spaces not insulated.
Space heating, distribution, heat source	Central waterborne system, floor heating (centrally regulated), fossil gas	Central waterborne heating, radiators (individually regulated), district heating	Individual systems and distribution, fossil gas. The building owner do not know what systems the tenants install, or in what state they are prior to retrofit
Ventilation system	Natural ventilation	Exhaust ventilation	Natural ventilation
Domestic Hot Water	Individual heating of DHW (fossil gas)	Central heating of DHW (district heating)	Individual heating of DHW (fossil gas)

In the following Figure 2, the layout of the exterior wall of each pilot is illustrated along with a presentation of the original U values incl. thermal bridges for the building envelope parts. The U values were calculated in the early analysis in the BEEM-UP work package 1, analysing the original state of the buildings.

In the following Figure 3, the respectively systems for heating, ventilation and domestic hot water are shown.

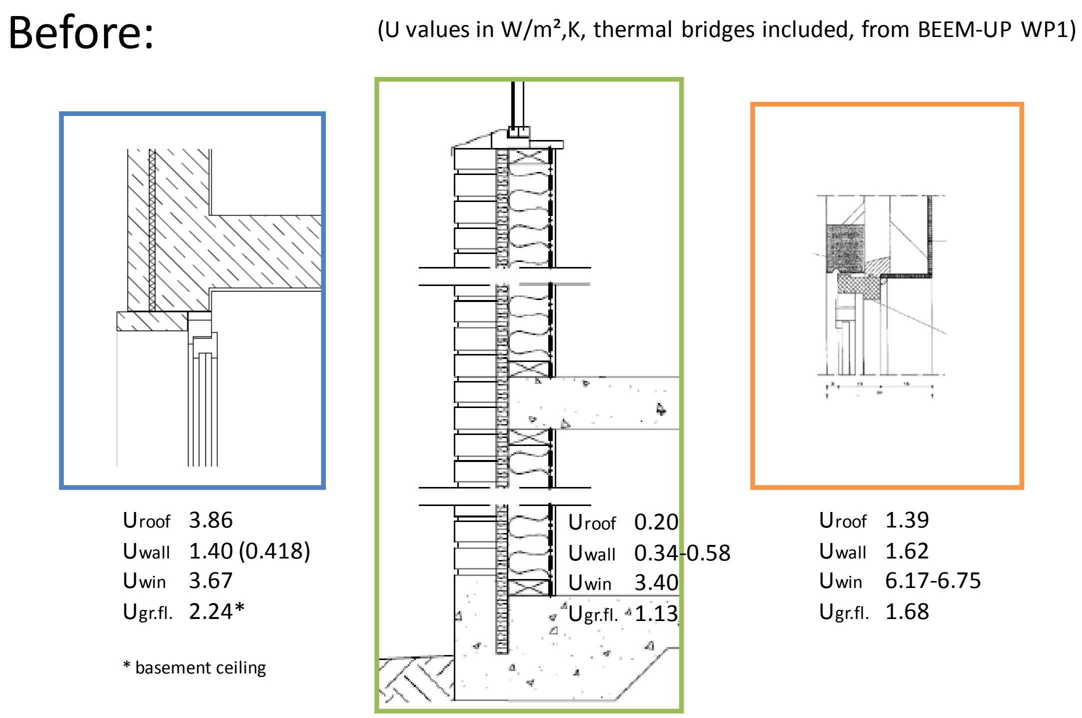

Figure 2 Building envelope before retrofit: Original wall types in (from left) Paris, Alingsås, Delft buildings. Regarding Paris, the wall U value within brackets refer to the supplementary insulated backyard façade.

In Figure 3 below, the systems for heat, ventilation and air conditioning (HVAC) and heating of domestic hot water (DHW) are described, along with what heat source that feed the systems. In Delft, heating system and distribution systems are owned by the tenant.

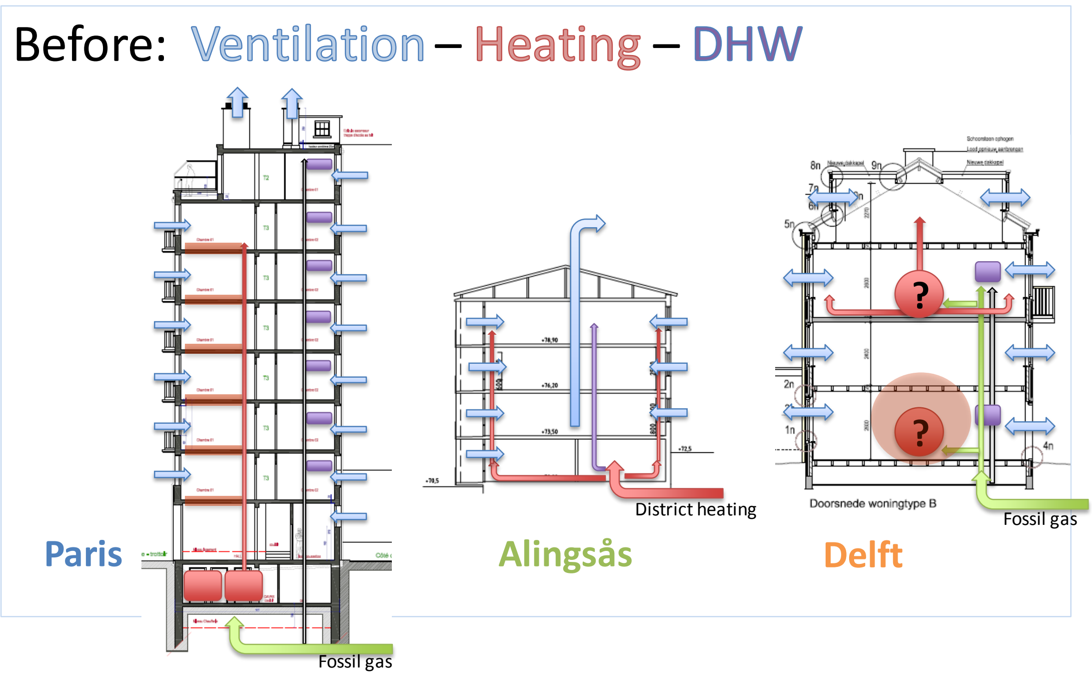

Figure 3 Building services before retrofit: HVAC and heat distribution. For Paris, the red boxes in the basement represent the collective boilers of the central space heating system. In Delft, heating and heat distribution systems are tenant owned and not known by the building owner before retrofit, therefore marked by question marks. There can be central systems fed by individual boilers, or just a single gas burner stove – old or new.

1.4.3 Technical measures - Building envelope

Table 5 below gives an overview of the building envelope related measures implemented in the three pilot sites, in terms of technology used and the resulting U values. The table is supplemented with some illustrating photos in Figure 4.

Table 5 Building envelope components of the pilots after retrofit, to be compared with Table 4

Source: [4]	***Paris, France:***	***Alingsås, Sweden:***	***Delft, the Netherlands:***
Foundation	110mm of slag wool on the basement ceiling 120mm of glass wool below external and internal passages ($U_{basement\ ceiling}$ 0.21W/m²/K)	Supplementary interior insulation of bottom floors in flats using polyisocyranurate. Extended insulation of bottom floor edge beams to prevent local heat losses. ($U_{ground\ floor}$ 0.17 W/m²/K) [5]	Insulation of suspended bottom floors using layers of reflective foil between floor joists and coverage of crawl space soil floors. www.tonzon.nl The insulation is only installed during flat vacancies (due to risk of asbestos during work in crawl spaces). ($U_{ground\ floor}$ 0.20 W/m²/K)
Exterior walls including balconies	Both façades have 180mm graphite EPS (the former insulation is removed from the courtyard façade). 50mm of high performing aerogel by Falguière balconies. (U_{wall} 0.30 W/m²/K) Only balconies on the street corner are transformed into bow windows.	Original inset balcony slabs are cut off, new exteriorly supported structures to avoid thermal brid-ging. Original walls torn down, rebuilt with airtight (q_{50} <0.30 l/s/m²), well insulated passive house walls (U_{wall} ~0.10 W/m²/K)	The exterior side of the brick wall underwent a cleaning, repair and hydrophobisation to reduce moisture and increase the insulation. (U_{wall} 0.22 W/m²/K)
Windows	Wood Double Glazing 10-16-6 Argon on street façade PVC double glazing 4-16-4 FE on the courtyard Aluminium double glazing 4-16-4 FE for balcony bow windows (Mean U_{window} 1.25 W/m²/K)	New triple-glazed cryptone filled low-emitting windows (U_{window} 0.85 W/m²/K) [6]	HR++ argon filled windows with a reflective layer. (U_{window} ≤ 1.2 W/m²/K)
Roofs/ Dormers/ Terraces	Supplementary 200mm PUR insulation on the roof 120mm of PUR on the terraces (U_{roof} 0.16 W/m²/K)	Original wooden roofs reinforced and reinsulated. 300 mm mineral wool on attic floors, 100mm on roofs. (U_{roof} 0.11 W/m²/K) [7]	Exterior supplementary insulation with 200mm elements of graphite enhanced EPS. New insulated dormers (100-150mm EPS) (U_{roof} 0.25 W/m²/K)

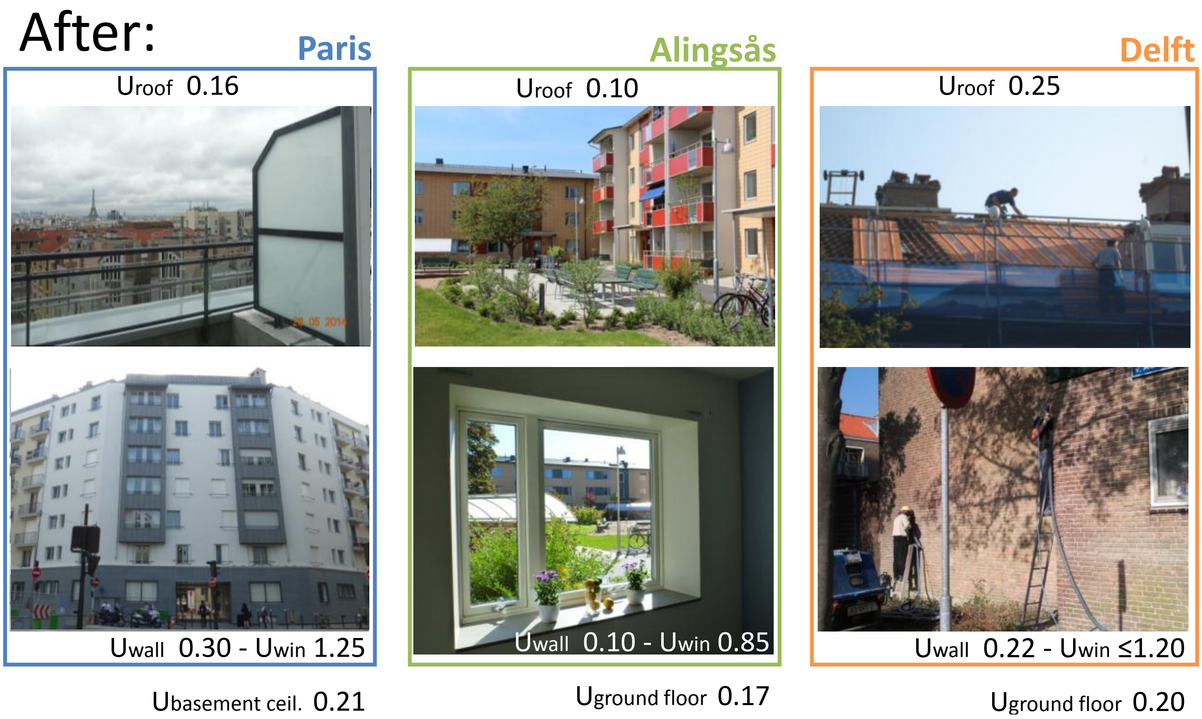

Figure 4 Building envelope after retrofit: Illustrations and U values [4] of the retrofitting of exterior walls, façades, windows and roofs for Paris, Alingsås and Delft respectively.

1.4.4 Technical measures – Building services and ICT systems

In the following Table 6, conditions for energy supply in the buildings after retrofitting are listed. Changes apply to heat supply to heating and DHW, HVAC systems and feedback systems (ICT) on energy use. Some illustrations of new installations can be found in Figure 5.

Table 6 Energy source and installation systems in the pilots after retrofit, to be compared with Table 4

	Paris, France:	***Alingsås, Sweden:***	***Delft, the Netherlands:***
Heat source	Fossil gas. Two new central condensing boilers (2*225 kW) Central grey water heat recovery	District heating (bio fuelled), heat recovery from outlet air	Fossil gas. Option of new condensing boilers and solar collectors per flat (about 50%)
Heat distribution (H)	Radiators with individual thermo-stat to adjust the central heating set point replacing floor heating	Airborne distribution with waterborne heat supply to air heaters, controlled per flat	Waterborne system with radiators offered, individually controlled per radiator
Domestic Hot Water (DHW)	Central system, a heat pump in combination with grey water heat recovery. Complement from the condensation boilers. Reducing frothers on taps.	Central system, district heating. Reducing taps.	Decentralised systems, heated by fossil gas. Water saving showers.
Ventilation (VAC)	Central system, humidity controlled mechanical exhaust system	Central system, mechanical supply and exhaust system with heat recovery	Natural ventilation. New windows equipped with ventilation openings
Information & Communication Technology (ICT)	Siemens Synco living system, displays in flats' videophones. Individual billing of DHW and heating is introduced. Focus on tenant behaviour, awareness-raising. 11% saving expected	Individual billing and feedback is introduced	Eneco Toon Display, displays in flats and smartphone apps: heating control, real time feed-back on gas and electricity

After, targeting a -75% energy demand for space heating

Different conditions – different measures

Figure 5 Building services after retrofit: Examples from the HVAC, DHW and ICT systems after retrofit for (from left to right) Paris, Alingsås and Delft. Tenants were also encouraged to switch to low energy lighting.

1.5 Common starting points for the retrofitting processes

Despite different national, financial and technical prerequisites, there are some similar starting points for the three demo sites.

Sustainability is a common aim in all three pilot projects; the energy efficient retrofitting should also be cost efficient in the long term and include social aspects such as indoor comfort and tenants' involvement in the neighbourhood as a whole. The organisational quality and involvement aspects developed and described below apply to most retrofitting projects to an overall or deeper extent.

1.5.1 Pre-evaluation with a holistic perspective going beyond State of the Art

Within the BEEM-UP project, the pilots are also supported with a methodology and competence to investigate and evaluate different retrofitting scenarios, to serve as decision support for what measures to choose. Through the holistic evaluation perspective, measures are assessed and compared in combinations in order to find the most efficient retrofitting package in all aspects.

Putting together expertise from different fields all around Europe, BEEM-UP also connected the pilots to a broad spectrum of State-of-the-Art technology for energy efficient retrofitting of multi-family buildings and enables a development of innovations beyond that.

1.5.2 Quality Assurance System

Besides the evaluations, pilots are also given a tool box to use to control and ensure the project objectives continuously through the retrofitting process. The Quality Assurance (QA) methodology has been developed in the BEEM-UP task 2.1.

A quality assurance system is a part of the BEEM-UP approach. In order to achieve the intended performance results, the QA system functions as a systematic routine and communication tool to ensure that right actions and right responsibility through all stages of retrofitting, commissioning and maintenance phase to meet the objectives of the project.

From a building inventory and interviews with tenants in the beginning of the process, requirements are set. These are to be followed up by identified actors in each stage of the project, to ensure that the right final result. The QA system also involves a post retrofitting follow-up of tenants' views on the energy performance and indoor environment of their flat along with measurements.

1.6 Resulting energy savings

All three BEEM-UP pilots have, through the retrofitting, achieved substantial energy savings. The energy performance of the retrofitted buildings are in many cases better than national averages or even better than requirements for new buildings in the same category. The energy use reductions for the three pilots are presented in Table 7 below. Although the savings in some cases deviate from predictions or project objectives it is clear that the retrofitting has made a significant difference in all three sites. Results, monitoring methods, discrepancies and lessons learnt have also been fully analysed in the report *D3.8 BEEM-UP Final reporting of monitoring results in all three sites* (public report) [4].

For the report in hand, the resulting energy savings are shown to enable a quantitative assessment of the retrofitting process in each pilot, in comparison to selected measures per site. As discussed in section 1.3.1, the energy share of main focus to the BEEM-UP project has been the reduction of space heating demand, which is the by far largest share of end use energy demand in dwellings in Nordic and Central European countries. However, the retrofitting of the three pilots have also seen to the reduction of the demand of domestic hot water and common and domestic electricity, through the measures presented in this chapter and by making tenants aware of their impact on their own energy bill through ICT.

The table below shows the average savings in actual *energy use* compared to the situation before retrofit. Hence, not just the resulting *energy demand* of the buildings is included in the energy performance, but also the behaviour of tenants before/after retrofit. For more information on assessments of energy performance, please see the [4] report as above.

Table 7 Resulting savings in energy use (in % of energy use before retrofit) The figures (see Table 7) derive from the monitoring programme of the BEEM-UP project, Work Package 3. For details, se [4].

	Paris, France	*Alingsås, Sweden*	*Delft, the Netherlands*
Space heating savings	- 60-65%	- 80% **	- 45%
Domestic Hot Water savings	- 52% *	- 12% ***	- 14% ****
Electricity savings	- 58%	- 35% ***	0%

*) Considering reduced heat losses in the DHW distribution circuit **) After optimisation of the system
) Average energy use reduction from two monitoring periods *) Average figure, results ranging from +50 to -55, depending on previous systems and measures chosen in each dwelling

Chapter 2 Retrofitting processes of the three pilots

This chapter gives a description of the specific retrofitting processes, including the most crucial experiences made by each demonstrator. To give a survey of the three projects, key figures of the sites are firstly presented and contrasted in section 2.1 Secondly; all three retrofittings are described chronologically. Finally, conclusions are made.

2.1 Key facts of the three projects

Table 8 below displays the fundamental facts concerning size and level of intervention of all three projects in comparison.

Table 8 Overview of project key facts

	Paris, France	***Alingsås, Sweden ****	***Delft, the Netherlands***
Dwellings per site (Before → after)	87 → 81 flats. Some flats are recomposed in the project	299 → 270 flats of 1-5 rooms each. Flats are recomposed in the project	28 row-houses / 84m² each → 80 flats / 92m² each
Level of intervention	Mainly energy measures Exterior and interior envelope measures and building services	Deep renovation	Exterior envelope measures and building services
Total area per site (Before → after)	4,352 m² living area	19,137 → 19,513 m² living area. Additional space is gained in the project	9,681 m²
Tenants evacuated during retrofitting	No	Yes (deep renovation)	No
Total project time	19 months	7 years excl design phase. 9 months per building,	Envelope 4 months, 1 month per street. Installations 6+ months.
Time affected per flat	Many interventions for plumbing (DHW and HVAC), electricity (meters and security upgrading), windows	9 months of evacuation	2 days for new windows; 1 day for installations
Total budget	€ 4,250,892 (about 2 M€ for energy measures)	€ 37,000,000 excl VAT (€ = 9,17 SEK)	€ 3,544,000 excl. VAT
Budget per flat	€ 52,480	€ 124,000 excl VAT	€ 32,800/flat or € 366/m²

*) Figures relates to all 16 buildings of the Brogården project, of which 8 are included in BEEM-UP.

2.2 Process of the Paris pilot

The BEEM-UP process differs quite a lot from the normal procedure of an ICF Habitat retrofitting. As a contrast to better show these differences, the usual ICF Habitat retrofitting process is described in Annexe 1.

Even though the BEEM-UP process itself is perceptibly different, a normal/direct tender type was used for all the contracts: Architect + Technical and Thermal Office (PC = Prime Contractor), Controllers, Construction Company. The energy demand per m² is also calculated differrently compared to a normal retrofitting project. Instead of the SHON surface (5759m² for the renovated surfaces of the Cotentin building) used for official energy calculations, the living area measure (4352m²) was used.

2.2.1 Early phases

The residence built in 1959 was bought by ICF Habitat Novédis in 2007. ICF Habitat Novédis had then planned for a retrofitting mostly because of the dwellings' winter temperatures: too cold in the upper ones and too hot in the bottom ones. The only solution to lower the temperature in the latter ones, with no heating regulation system in the dwellings, was to open the windows. The tenants were complaining about these problems to the ICF Managing Agency.

The floor heating system used in the dwellings did not comply with the adding of a new regulation system. Thus the solution for the residence was to change all the heat emission system, which came along with generators' change, and to insulate the building envelope.

This work package was too extent to be conducted by the Agency solely. Therefore Novédis Assets Direction established a work proposal including additional electrical and security upgrading as well as an important embellishment of the outsides.

This was before the integration to the BEEM-UP consortium. When ICF Habitat Holding and the Sustainable Development Department decided to participate in BEEM-UP in order to impulse a new run-up for the energetic renovation of its assets, ICF Habitat Novédis proposed to apply the experimentation on Cotentin residence.

2.2.2 Design

Several diagnoses were established by both the Technical and Thermal Office chosen by Novédis and the partners from BEEM-UP Consortium.

A new retrofitting program was then established with the BEEM-UP partners, Novédis' Assets Direction, chosen Architect and Technical Office and ICF Habitat Holding, including project management, innovative materials and technologies and tenants' involvement. The aim was to apply various measures to the three European pilot sites in order to compare and select a large scale applicable retrofitting method.

2.2.3 Execution

For this phase Novédis chose the Construction Company Brezillon because of its management of tenants' interaction. Brezillon is a general contractor who employs many subcontractors.

One person of the staff is dedicated to the communication with tenants and to attend to their requests as far as possible. This was specified in the contract, as it was very important for Novédis and for the success of this huge retrofitting program applied to an occupied building.

2.2.4 Quality Assurance

For this retrofitting ICF Novédis had a certification process PH&E with Cerqual which, besides the environmental requirements, includes an important management effort. The construction company Brezillon has also an internal quality process which was added to the contract.

For the particular use of the innovative thin insulation material the project applied a specific quality process. The supplier and BEEM-UP partner BASF sent an expert and a translator from Germany to explain and show the implementation technics to Brezillon's foreman and workers. Fully illustrated documentation was also provided with some auto-control forms to be returned to Novédis and the Scientific and Technical Center for Construction.

2.2.5 Schedule

2007	Residence acquired by Novédis
Starting 2009	First approach to Energy Saving retrofitting with Luwoge Consult
19/05/2009	First Visa agreement by ICF Habitat Holding on the residence's retrofitting
09/2009	Engagement act for the PC (Architect + Technical and Thermal Office)
Ending 2009	First diagnosis, audit and energy-economic scenarios
15/05/2010	ICF Habitat accepted in the BEEM-UP project
02/09/2010	PC's tender
08/02/2011	Start of common design with BEEM-UP consortium
07/07/2011	Second Visa agreement by ICF Habitat Holding
10/10/2011	First presentation of the program to the tenants
16/04/2012	Second presentation of the program to the tenants
15/07/2012	Construction tender document finalized
05/12/2012	Brezillon's mission order: 3 month for preparation and 12 month of work)
12/2012	1st amendment to the design program for window frames' change
07/2013	2nd amendment to execution for meters' change
01/03/2014	Start of Operations Prior to Acceptance of Work in the dwellings
01/10/2014	End of work / Acceptance of Work (except from the electrical riser and the plantations to be done in October)

Total time span for the complete retrofitting was 19 months.

2.2.6 Lessons learnt

The main lesson to learn is that the monitoring programme needs to be very well defined in advance when ICT is introduced in a project. The retrofitting of the French pilot was delayed by in total 7 months, to a great extent caused by a lack in program definition where it was not specified how the consumptions should be reported to the tenants. This has been solved during the work process in successful but time consuming communication between Novédis, Brezillon, Siemens and Urmet. The project delay also caused disturbance to the post occupancy measurements in the BEEM-UP project, as the measurements in Paris had such a late start.

Organisation-wise, 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) might have played a role for the information diffusion.

In addition, a special attention must be paid to measurement data units in the different European countries. For instance, the definition of a building's surfaces varies a lot. Only in France there are three commonly used types of surface measurement units for the very same building. This causes huge differences when comparing the energy use per m² between different buildings and countries.

Figure 6 The Paris building during retrofit (source: ICF Novédis)

2.3 Process of the Delft pilot

The construction process of the Dutch pilot was split in two parts, one focusing on envelope measures and one on building services. This section explains the organisational implications on the process and how the project was altered as a part of the BEEM-UP project.

2.3.1 Early phases

The project in Delft was originally delayed in 2009 and in fact, also in 2010, before starting in 2011. This is an important background as it explains some of the cold feelings the tenants had towards Woonbron from the very beginning. Besides, aluminium frames installed in the buildings during the eighties were never a success and in the winters some dwellings would have ice on the inside of the glass.

As standardised in many retrofitting projects, Woonbron started the process with the formation of a group of interested tenants to inform and to build up a relationship with regards to decision making and general agreement about the process and the content of the refurbishment. This group was led by the developer company that is owned by Woonbron.

When the BEEM-UP project came into place obviously ambitions were raised, in particular with regards to neighbourhood involvement, behavioural aspects and installations. Since the agreements with the tenant group was already made and the most important promise was to fix the windows before Christmas, the BEEM-UP alterations were presented as extras and the refurbishment could start as planned.

Much to the disappointment of BEEM-UP partner Dura Vermeer, who had invested time in energy-efficient scenarios, a normal tender procedure took place to find a contractor who was then chosen on lowest price.

2.3.2 Execution, envelope refurbishment

At the early start of the refurbishment, some of the tenants endured large problems when heavy rains came around in the weekend, and the roofs in repair appeared to be non-waterproof. Some other problems arose in the first weeks. A couple of these had to do with final specifications not being communicated to the tenants clearly enough, in particular with regards to the windows that were installed in the showroom house, and the ones that were eventually chosen.

Since all the windows were indeed installed before the promised deadline of Christmas, the contractor could be satisfied, but over all there were too many complaints with regards to behaviour of the builders, unfinished work, or in some cases poor quality of the work.

The actual BEEM-UP extras, technically most apparent as solar boilers, feed-back systems and floor insulation, were being communicated and planned shortly after the installation of the windows and finishing of the envelope refurbishment.

2.3.3 After the envelope refurbishment – execution of BEEM-UP add-ons

As what perhaps could be expected with the lowest cost contractor, the finalisation of the envelope refurbishment took quite some time. Furthermore, some unfortunate repairs also had to be planned and performed to the retrofitted buildings. It was clear that the extra BEEM-UP installations were not in line to be put into place yet.

Since the Dutch BEEM-UP measures (in terms of building services and floor insulation) did not have to be planned at complex level but much more as individual dwelling-level-projects, the timing of the installations was much more loosely organised in 2012. The tenants were given time to react to the solar boiler offer, but also to order one, when they saw one being fitted at their neighbours. Although this has led to lots of movements for the installers, the extra time also made more people choose the solar energy concept.

In the autumn of 2012 it became clear that there was a systematic installation fault in all the solar boilers and the systems needed to be adjusted. The floor insulation offer was later abandoned since there was found to be a risk of asbestos under the floors. Woonbron could not take the risk of exposing the non-evacuated tenants to the asbestos. Now, floor insulation is therefore only applied when a tenant moves, before the new tenant moves in. The Toon (Eneco) feed-back systems were applied with or after the installation of the solar boilers and were received just in a time when the Eneco mother company started their marketing on national television.

2.3.4 Lessons learnt

As described above, sub-optimisations 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. New technology might also take a little more time and effort to implement in design, installation and adjustments.

There were some problems with lacking trust from the tenants towards Woonbron and differences between expectations and real measures. The BEEM-UP extras were being communicated through different channels, basically by Woonbron Delft and not the developers company. This was not always clear to the tenants and they were also surprised by the rather positive actions from the BEEM-UP tenant involvement group, such as giving boxes full of energy saving measures/equipment. The slow communication process appears to be successful, as in the end, many tenants chose to go for the BEEM-UP extras.

Refurbishing in a situation where the tenants stay in their house requires extra attention for their wellbeing and attitudes of the workers. However, in interviews in 2014 all interviewed tenants spoke about their satisfaction with the results of the refurbishment.

Figure 7 The Delft buildings during installation of solar panels (source: Woonbron)

2.4 Process of the Alingsås pilot

Since the Swedish pilot project started in 2007, only half of the 16 buildings of the area were included in BEEM-UP (144 flats out of 299). However, this section tells the story of the project as a whole, hence including decision making and early phases from before BEEM-UP.

2.4.1 Early phases

The buildings and the neighbourhood of Brogården is regarded a long term commitment by the owner Alingsåshem. The area was well-loved, even though it had technical defects and poor accessibility. Therefore, it was important not to tear down the houses and build new ones, but to preserve the established homes and give the neighbourhood a new life with a long term perspective. In line with the sustainability targets of Alingsåshem, this had to be done in a socially, ecologically and economically sustainable way. Furthermore, Alingsåshem's mission involves providing housing for everyone, independently of size of household, age or income.

With this holistic and long term perspective, Alingsåshem saw the social benefits of a neighbourhood development that includes accessibility, home care service, shared facilities etc. from a municipality point of view. Ecologically, the initial aim was to significantly reduce the high use of energy and rising energy costs in Brogården. Financially, different retrofitting scenarios were calculated and compared for the whole prolonged life cycle of the area in order to find a profitable approach. By using the real time scale, solutions with low life cycle costs can be found even though they are more expensive initially.

In order to work as a team, reinvest all experiences in the project and involve everyone – designers, contractors, property managers and residents – in the development process, Alingsåshem decided to use the collaboration model *Procured partnership*. The partnership is a structured and modern form of collaboration characterised by trust, transparency, shared goals and dedicated partners. Partners form the project together and the focus moves from contract management to common solutions. The expected benefits are production and cost efficiency and continuous improvement of products and service.

2.4.1.1 Decision making

The partnership started with a different approach to the tendering process in traditional construction projects. The competitive bidding was based on both profit margin and employee skills. Alingsåshem's call for tender asked for the right team of people to develop the retrofitting project instead of suggested costs for a set project. Every Skanska employee to be involved in the project – all officers and some of the skilled workers such as the safety delegate and the foremen – wrote a personal application letter explaining their goals and drives for the project to be presented along with the company's competences, support and vision. The applications were also completed with personal interviews before the contractor could be selected.

After the agreement, the design process started with everyone in the team involved, based simply on the state of the existing buildings and the mission to remedy the defects while preserving the soul and enhancing the existing qualities of the area. The building owner, the main contractor and the subcontractors for electricity, plumbing, painting, landscaping have been contracted in partnership agreements. For the last stages also the demolition contractor has been seen as a possible partnership actor, since their quality of work is of great importance to a retrofitting and for the following teams to rely on.

The tenants were involved from the very beginning, to give their view on qualities of the area and improvements needed. Among them, the need for more accessible flats for all became obvious. The information and discussions were arranged by Alingsåshem and the local Union of tenants in cooperation. Later, the contractor would be helping out by informing about what was going on at the worksite in a monthly newsletter handed out to all tenants. All rent increases were negotiated with the Union of tenants. This process is a requirement by the Swedish law, but was also an opportunity of open dialogue between the building owner and the tenants.

For the retrofitting team, the project started with a one-day project kick off meeting when Alingsåshem shared their visions for the project and all teams – designers as well as contractors – agreed on common objectives for the project. Every one of the six project stages to come later, each involving a number of buildings, were to start with such a kick off meeting, involving all staff employed on site, sharing experiences; evaluating the previous stage and agreeing on goals and improvements for the next one.

2.4.2 Design

The design phase took off in 2007. The most important milestone technology-wise was when the project was transformed from a retrofitting with energy efficiency measures to a passive house project. The idea was grasped by Alingsåshem's CEO Ing-Marie Odegren who realised that turning the buildings into passive houses would coordinate the goals regarding energy performance and indoor environment in a common methodology and focus of the project. Technically, the technology focuses on a high thermal insulation rate and minimisation of thermal bridges, very good air tightness in the building envelope and mechanical ventilation with efficient heat recovery (HRV).

The building owner, architect, designers and contractors and experts in such fields as passive houses and accessibility formed the design team. This was much of the benefit of the contractor, given influence on early decisions that have large impact in the construction phase, such as logistics and detailing affecting the methodology. A famous Gordian knot of the design phase was the new solution for the balconies. The original indented balconies were a problem to every profession involved. They were small, dark, and bad in terms of accessibility. Furthermore, the existing geometry obstructed construction logistics, complicated the air tightening layers and insulation procedures and created a significant thermal bridge with bad thermal comfort and uncalled-for energy losses of the flats. The emerging idea to cut them off and include the former balcony floor area in the flats solved all these problems and added an additional four square meters per flat. Instead, new, large and accessible self-supporting balconies were erected exteriorly.

A turning point of the process from an efficiency point of view was when the design team started treating the houses in groups of similar buildings, using the same blueprints, instead of redesigning one building at the time. Work was planned to be done methodically from one end of the area to the other.

2.4.3 Execution

The construction phase started in 2008 with a pilot building, and finished in August 2014. Evaluations have been made after each finished building. The buildings were stripped down to the concrete load bearing structure, and then rebuilt using passive house technology. High accessibility indoors and outdoors has been obtained in the entire area.

The procured partnership model includes the financing, with a common and open budget and open accounting. The profit of the contractor is a fixed amount, and every added costs or savings are split equally between building owner and contractor, thus also sharing the incentive of cost savings. The budget and accumulated costs so far has been discussed regularly in meetings between the partners, which was an important part of the project management.

All tenants were evacuated during the refurbishment and enabled to move back once the renovation of their flat was finished. Because of this, evacuated houses, buildings with ongoing construction works and inhabited houses have stood alongside each other all through the project. Thus, safety of tenants has been a vital issue for the contractor. For all 299 households, the ongoing refurbishment has made a notable impact on their daily lives during the project time and the dialogue and communication between the project, the building owner and the tenants has been of vital importance.

Buildings inspections were conducted as self-inspections carried out by the foreman of each trade. Alingsåshem set the desired standard of delivery of all systems, building services, envelope and interior surfaces and equipment. The self-inspections meant a more distinct responsibility for each trade and each worker, where everyone on site is aware of their contribution to the final product. This shared goal strengthened the participation and the pride of each individual, all contributing to the final result. During the process, project members of all different trades also shared their experiences, evaluations and ideas of improvement of the technology and the process itself on behalf of the project.

2.4.4 After retrofitting

Through the implementation of passive house technology, focusing on high energy performance and good indoor climate conditions, the energy demand of the Brogården area was significantly reduced.

Ecological targets were met through a reduction of more than half the energy used for heating, domestic hot water and common electricity, while keeping the renewable district heating as heat source. Socially, surveys show that the tenants are happier with their homes after than before retrofitting.

The essential goal to keep the soul and qualities of the Brogården homes was met, and most tenants were able to move back to their old flat if they wished to do so. Tenants were also well involved in the design and facilities of shared spaces. The accessibility rate of Brogården flats is now as high as 60%, meaning that elderly or disabled people can stay in their flats instead of moving to a nursing home. The buildings are also prepared for additional facilities as bed lifts, door openers and adjustable kitchen equipment to be installed if needed. Other accessibility measures, like larger bathrooms, low placed installations, shelves and hooks, are for the benefit of all tenants – e.g., even a child can now reach the entryphone.

Economically, targets were met by well investigated alternatives and open books with regular reconciliations. The investment is high, but the retrofitting project is calculated to be profitable to the building owner in 11 years' time. If nothing had been done to the area, the calculations show that the area instead would be a loss project from 2030.

2.4.5 Lessons learnt

An important task was to introduce the tenants to a new and different heating and ventilation system, and to facilitate the everyday use of it. This is a communicative challenge.

The deep renovation and sharp energy focus mean that future financial risks are reduced, as costs for operation and maintenance will be significantly lower after retrofitting. There is also a transaction of future behaviour-related risks of energy costs from the building owner to the tenant, as tenants after retrofitting get in charge of their own energy bills and possible savings. Before, costs were included in the rent, which did not encourage energy savings. The improvement of quality of the buildings and the status of the neighbourhood will also minimize future financial risks such as vacancies.

The project has in total been very successful and this is, according to many partners, 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.

Figure 8 Retrofitting of the last court – buildings before, after and during intervention

(source: Skanska)

2.5 Common success factors

To conclude the three stories, the outcome from the pilot projects shows that the organisation of the retrofitting process itself is a very important key to a successful energy retrofitting. Here, a few of these organisation and involvement factors are illuminated.

Process-wise, the involvement of tenants has been found to be an important aspect in all three sites and is thoroughly developed within BEEM-UP. In the retrofitting process, communication is a key issue. Tenants are informed about actions planned, what's happening and why. In Sweden, coffee and cookies were shown to be a good way to open up the discussion when building owners invite tenants for information meetings. In the Netherlands, the building owner representative challenged the tenant group that he'd make them a cake when the process had finished, and so he did. Where problems have arisen, they have mainly been related to increased disturbance to tenants (additional visits to flats etc.) or what the tenants experienced as abandoned promises. Both risks can be reduced by information, but the communication and subject are important if the tenants shall be content. Too much or vague information was not appreciated.

Still, the involvement goes much deeper than bare socialising and information. Examples from BEEM-UP tenant involvement are such as workshops and inquiries to get the tenants' views on the measures, accessibility and planning of common areas. The issue of living in the retrofitted and more energy efficient dwelling is well addressed.

Information and leadership is very important, including the planning and coordination of works and the ambitions of contractors on site. It is important that works are carried out in time and that the quality of performance is on the required level, so that repeated visits to flats or other disturbance to tenants, or the project as a whole, can be avoided. As some actors will be leaving during the project time, to withhold the engagement and the information and involvement of new members is crucial to the organisation.

To anchor the process in the organisation is a question of communication. Apart from the tenants, 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 QA 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 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. The QA process has been developed within BEEM-UP.

Another involvement parameter shown to be very important in the retrofitting process is the personal competence and engagement of building owners, designers/expertise 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.

Annexes

Attached to this report is firstly the description of a normal retrofitting process of ICF Habitat/ICF Novédis, the French building owner, to contrast to and to better explain the level of innovation in the Cotentin retrofitting project. Secondly, the illustrated and continuous full process documentation made on each site is enclosed to show the journey from start to finish. These progress reports have also been continuously published on the BEEM-UP website (www.beem-up.eu) during the project.

Annex 1: Usual retrofitting process for ICF Habitat (FR)

Annex 2: Monthly updates from the retrofitting process in:

- Paris (FR)
- Delft (NL)
- Alingsås (SE)

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Annex 1: Usual retrofitting process for ICF Habitat (FR)

Stakeholders:

- 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
- Tenants

1. Planification

   The needs of ICF Habitat are related to those of the SNCF (Railway National Society), which is its main shareholder, to house its employees.

   In practice, the priority needs are often the rendition of tenants' requests about the hydrological and thermal comfort of their homes to the Managing Agency. When too complex disorders cannot be solved by the technical division of the Agency, they are taken over by the Subsidiary's Assets Direction.

   This one also has two tools which cross-analysis allows detecting directly the buildings to treat in priority.

   - The SDE (Energy Guiding Scheme) developed by the Holding specifies the energy quality of buildings in terms of their consumption and their technical characteristics (loss surface × insulation, heating and DHW).
   - The PSP (Assets Strategy Plan) specifies guidance to 10 years for buildings in terms of geographical (declining employment area, closed railway station) and typological interest. Part of the assets is thus sold to third parties or from Novédis to Social Subsidiaries.

   The Assets Direction of the Subsidiary then develops a work proposal to the attention of the Visa Committee whom decides on the financial relevance of the project and any changes. The Visa Committee members are the senior officials of ICF Habitat Holding and representatives of the SNCF.

   When the work proposal and its expected schedule are accepted, then the Subsidiary launches the Design phase.

2. Design

   The design process is more rigid when it comes to social housing (partially funded by the State) as the PC market must go through a public call for tender, forcing the ICF PO to define very precisely the needs upstream.

In the case of free housing, ICF Novédis can choose its PC and develop the program more easily with them.

PC is contracted on its retrofitting program amended with the PO. The PC contractual missions are strictly regulated by law and include mandatory ones:
• The study phase is a dialogue between the Subsidiary and the PC at each stage: sketching, preliminary draft, final draft, project, construction tender document, assistance for constructor choice.
• The PC mission during the construction phase is to oversee and monitor the work of the selected company: validation of execution design, management of work execution. The diagnosis is an optional task often entrusted to the PC.

The execution design documents are also controlled by the Control Office, the Safety and Health Protection Coordinator (building regulations), and optionally by the Asbestos and Lead Controllers and the Certifying Body.

3. <u>Execution</u>
The works is entrusted to a general contractor or a consortium in separate lots, selected on call for tender (not mandatory in the case of free rent) in response to the Specifications written with the help of PC.

Within the Subsidiary, a Project Manager from the Assets Direction follows up the work. It is not always the same person as the work proposal editor who initiated the renovation program.

- The PC supervises the execution of work contracts.
- The Construction Company can make use of subcontractors after their validation by the PO.

Controls are carried out regularly by the Control Office, the Safety and Health Protection Coordinator and Asbestos Controller. They alert the PO on regulatory issues and may request changes of work. To promote innovation, the PO may override the requests of the Control Office by ensuring risks with additional insurance.

At the end ok work there are several mandatory procedures:

- Operations prior to the Acceptance of Work where the PC validates the work performed by the Construction Company or asks for corrective actions. These allow avoiding a maximum of reservations by the PO when the PC officially handed him the building at the Acceptance of work.
- From the Acceptance of Work runs the Year of Perfect Completion during which the Construction Company has the obligation fix at its expenses all the reservations but also all the disorders that can appear during a full cycle of seasons.

4. <u>Quality assurance</u>
   Within ICF Habitat the quality of projects is provided in several ways.

- The Project Manager following the work may ask the Holding technical referents to answer some interrogations.
- The Subsidiary may include clauses requiring quality procedures in Constructor's contract.

Environmental certification is a good way to ensure the quality since it requires a procedure for management of the project and indicators.

Finally, the Subsidiary may also hire a Project Management Support in case of certification or complex issues such as asbestos.

Annex 2: Monthly updates from the retrofitting process

This attachment consists of the continuous process documentation that was made on each site during the respectively construction project. These updates were also continuously published on the BEEM-UP website (www.beem-up.eu) during the project to show the ongoing progress in the demonstrators. The updates follow the time span of each site process, thus varying in extension and content as the organisation and time plan of the projects were very different.

Monthly updates are presented for:

- Paris (FR) 2011-2014
- Delft (NL) 2011-2012, post occupancy wrapped up in 2013
- Alingsås (SE) 2011-2014