Energy Efficient Retrofitting demonstrations

- Can individual examples support replication for a Massive Market?

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Abstract

The 2020 and 2050 energy reduction targets of the *Energy Performance of Building Directive* (EPBD) calls for a strict focus on energy efficiency in retrofitting projects with currently high use of energy, especially today's great number of European multi-family dwellings from the 1950-1970s. In order to address a wider market, rational and effective tools, methodologies and construction processes need to be developed and tested in real projects serving as a demonstration for future projects and to support a massive market uptake and replication of methods found to be successful. The EU BEEM-UP project aims to do this through three different demonstration projects – Paris/France, Delft/the Netherlands and Alingsås/ Sweden – where knowledge will be developed and spread to other European stakeholders.

To find out whether achievements and lessons learnt by these three retrofitting projects can be useful for replication on the European market at a larger scale, the following approach has been followed;

- *Representativity*; for which types of buildings and projects can the examples apply?
- *Applicability*; for what conditions can different measures be useful?
- *Target groups*; what measures and actions appeal to which stakeholders?

The demonstration buildings are found to show a high representativity in the European building stock. Among the three countries involved more than 1.5 million dwellings matching the pilots are expected. Construction-wise, the concrete and masonry structures with/without wooden supplements as well as simple building services with a high use of heat and electricity are very common among European multifamily dwellings from the 1950-70's. The economic and legal conditions of the building owners also show examples similar to other Europeans. Thus, energy efficiency measures taken in the three pilot sites and described in this paper are expected to have a high applicability to other buildings, building owners and possible future retrofitting projects around Europe. Through the BEEM-UP project, these examples can be spread to possible followers via building owners, contractors, consultants, tenants and local decision makers all around Europe.

Keywords: EPBD, energy efficient retrofitting, demonstration, conditions, retrofitting process, technical measures, representativity, applicability, target groups

Introduction

The 2020 and 2050 energy reduction targets of the *Energy Performance of Building Directive* (EPBD) calls for a strict focus on energy efficiency in retrofitting projects, since the majority of the existing building park with its currently high use of energy will still be in use for decades ahead. This especially addresses today's great number of European multi-family dwellings from the 1950-1970s. Hermelink and Müller [2010] draw from a set of German case studies applied to the conditions of twelve other EU countries the conclusion that deep renovation is needed to meet the EPBD targets, but also that real examples will support the conclusion that deep renovation can be the preferred approach both economically and ecologically.

To address a wider market, rational and effective tools, methodologies and construction processes need to be developed and tested in real projects serving as a demonstration for future ones, to support a massive market uptake and replication of methods found to be successful. This demonstration involves target groups such as building owners, contractors and suppliers, but also policy makers and governments aiming at achieving the EPBD objectives on a higher level.

Aiming at the need for demonstration, the EeB initiative (*Energy efficient Buildings programme*) and 7th Framework Project have initiated the BEEM-UP project, *Building Energy Efficiency for Massive market Uptake*. Through three different demonstration projects in different EU countries – Paris/France, Delft/ the Netherlands and Alingsås/Sweden – knowledge will be developed and spread to other European stakeholders.

A key issue is found to be the identification of what achievements and lessons learnt by these three retrofittings that can be useful for replication on the European market at a larger scale.

Method and Objective

The BEEM-UP demonstration pilots in Alingsås, Delft and Paris will be followed throughout their respectively retrofitting projects. This paper describes the scope of the Work Package 2 (WP2) of BEEM-UP. Within WP2, the full retrofitting process and execution of work of each project, including both organisational and technical measures, is to be documented during the project period of four years. In 2014, the final results will be compiled and evaluated in terms of replication. In order to make an early assessment of the replication potential of experiences and results to be made within WP2, the conditions of each demonstrator will be examined in this paper in the light of the following aspects;

- *Representativity*; for which types of buildings and projects can the examples apply?
- *Applicability*; as local objectives vary depending on national building regulations, traditions and financial systems throughout Europe, for what conditions can different measures be useful?
- *Target groups*; what measures and actions appeal to and can be further developed by which stakeholders?

To show the scope of WP2 demonstration, the three BEEM-UP demonstrators will be thoroughly described to pattern the range of representativity within the project. For future retrofitters, the possible applicability of technical or organisational measures evaluated within BEEM-UP will much depend on whether the boundary conditions of the project are similar. Finally, the main target groups of demonstration are stated.

The input material consists of findings so far from BEEM-UP work packages, in particular from WP2, but also related information gathered from early investigations made within WP1 (Design for energy optimisation), WP4 (Technology innovation) and WP6 (Exploitation and market replication). By the final reporting of BEEM-UP in 2014 the WP2 compilation and evaluation of the full retrofitting processes and novel solutions will be complete. The conclusions drawn from the construction phase will, along with the analyses from other BEEM-UP work packages such as WP5 (Tenant involvement) and WP6, aim to fulfil the demonstration objective of BEEM-UP in terms of representativity and applicability for replication in order to enable a massive market uptake via the target groups identified.

The Demonstrators and their representativity

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

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 (estimations by ICF Novedis and the TACKOBOST project) Situated in an urban city area close to the Gare Montparnasse railway station.	***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 (estimations from Woonbron) Situated along five more quiet streets outside central Delft.	***Alingsås, Sweden***: Eight 2-4 stories multifamily buil-dings grouped around courts *) Built in 1971-73 144 flats; 400,000 alike in SE (estimations by Hans Eek, Architect MSA/SAR, for Brogården project) Arranged around large car free courts in a green environment on walking distance from the town.

**) The building type, structures and area layout is very similar to examples 21 and 23 of Så byggdes husen 1880-2000 (in Swedish) [Björk et al, 2002]*

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.

The diverse building types of the three pilots enable a larger replication potential as this widens the range of buildings and areas alike or similar around Europe. The following chapters will deeper penetrate the conditions for the demonstrators – the building owners, national and project specific requirements and the qualities and defects of the buildings in their the existing state – to better pattern what kinds of buildings the demonstration projects exemplify and for which conditions the projects can serve as inspiration to replication.

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*:**	***Delft, the Netherlands*:**	***Alingsås, Sweden*:**
Company	ICF Novedis - a subsidiary of ICF group, with 100,000 dwellings, which belongs to the French railway company SNCF. ICF Novedis manages 16,000 dwellings targeted at railway employees.	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.	AB Alingsåshem is a public housing corporation in the muni-cipality of Alingsås, Sweden. AB Alingsåshem owns 3,300 dwellings and builds approxi-mately 50 new dwellings every year.
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´s policy is to build at low-energy standard for all individual housing.	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.	To provide dwellings for every-one 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..
Tenants and client relations	In ICF Novedis only railway employees with a special rent contract agreement as a part of their work contract with SNCF. Dwellings can be sold to sitting tenants, but the housing company takes a decision. Housing benefits are available for the poorest – rents subsidies. 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.	Tenant households with a yearly income below €34,000 for rental flat. Priority for people with relati-vely 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. Rent increase is related to in-come of tenant. In complexes rent-increase can be made man-datory if 70% of the tenants agree on the measures proposed.	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. Tenant typology for varying and adopted offers. Municipalities can decide to sell dwellings.
Ownership structure	Tenants own their own white goods.	Tenants sometimes own their own heating and heat distribution systems, sometimes they rent it. White goods and floor carpeting are tenant owned.	Shared laundry facilities. Kitchen white goods in flat is owned by the building owner.
Consumption billing, before	The building owner pays heating, water and common electricity. Individual household electricity is directly billed to the tenants.	Tenants pay their own gas and electricity consumption, which are both individually metered.	The building owner pays central heating, common electricity and domestic hot water (DHW).

The property owners encounter different economic and legal conditions. Even though all housing organisations work within certain legal frameworks defined by their states, the circumstances differ signifycantly depending on the country. In both France and the Netherlands social housing organisations are non-profit entities with a legal task to provide housing to disadvantaged people and low-income target groups who cannot otherwise afford it. AB Alingsåshem, as opposed to other property owners in the BEEM-UP project, is considered a public housing organisation. In principle in Sweden the concept of social housing is not used. AB Alingsåshem as other public housing companies in Sweden operates on business-like principles and has a general interest objective – to provide housing in their municipality for all kinds of tenants. In contrary to social housing companies in Western Europe, AB Alingsåshem does not focus only on housing for the most vulnerable people, therefore there are no income limits for tenants. Furthermore, different from Sweden, social housing companies in France and in the Netherlands benefit from a favourable interest rate on the capital market due to their governmental security structure.

Housing companies treat each refurbishment as a unique project, which is related to a specific business proposal. The investment approach of social and public housing differs from the basic economic principles. Since social and public housing entities are organisations with a social mission, investment decisions are not only based on financial indicators. Social aspects, environmental concerns, accessibility of buildings and indoor conditions are considered as important indicators within a decision-making process. Consequently in some cases (e.g. in the Netherlands) there are possibilities of implementing an investment even if a business-case has a negative cash flow. If a refurbishment is needed, there is a possibility to add funds from sales or more positive projects.

Since housing companies mostly provide rental housing, the value of buildings and their increase of market value are not the most important indicators for an investment decision. An analysis rather considers a housing stock as an asset, which generates income from rents. However, in some specific cases e.g. in the Netherlands there is a possibility to sell some of the dwellings within a complex in order to finance the refurbishment. In Sweden, an entire public complex of dwellings can be sold to enable renovation in other shares of the building stock.

National and local requirements

Some different demands apply locally, as the energy requirements in national building codes;

- **In France**, the Thermal Regulation for existing buildings apply, 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/m^2,yr. Since 2010, the demand has to be reduced to between 80 and 165 kWh/m^2,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 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.

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

Other legal requirement, local requirements or demands that may apply

Additional technical requirements or boundary conditions can apply to a specific project, 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

The Swedish building code for instant states that RH in building materials must never exceed 75% due to mould risk. For well insulated buildings this means that wooden materials must be exteriorly insulated. In the Netherlands, the building decree calls for a 2% yearly reduction nationally in the use of fossil gas. The French pilot is situated in an area of historical importance which limits what exterior measures that can be allowed by the community. In Sweden, the architectural expression of the area as a whole was kept and developed in a dialogue with local authorities.

Traditions also imply, e.g. Dutch tenants normally expect natural ventilation. As Swedish construction methods historically often involves timbering, common 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. For reasons like these, methods considered to be normal in some countries might seem odd in other.

Finally, project specific demands and technical directives from the building owner can also differ. All building owners have sustainability targets. The Dutch building owner has a specific annual 3% reduction target in CO_2 equivalents and the Swedish low energy target aimed the project for passive house technology. Socially, Delft and Paris did not evacuate their tenants and needed to limit the disturbance from construction works. Alingsås wanted to increase the accessibility of the area and diverse the sizes of flats in order to attract more different groups of tenants.

Focusing on the national EPBD goals, it is clear that actions are primarily needed to reduce energy use for space heating, DHW and common electricity in all three countries. Space heating is also the overall highest share of domestic use of energy on EU and national levels, with an EU average of 68% [Odyssee-Mure 2012]. 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 and the reduction of energy demand through heat recovery and upgraded equipment.

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 for other projects. The replication potential of specific measures tried within BEEM-UP is higher to projects with similar systems, problems or qualities; therefore an overview is needed of these conditions.

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. 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: WP1	***Paris, France:***	***Delft, the Netherlands:***	***Alingsås, Sweden:***
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	Specific identity and quality Quiet area close to town centre with small scale buildings Traditional architectural expression of buildings and brick façades and popular gardens	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
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 condensa-tion/mould, poor sound proofing. Draughty windows. Bathrooms, kitchens, staircases need renewal	Façades need maintenance. Poor roof insulation and windows Large variation in heating sys-tems 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	Frost wedged façades need replacement, poor insulation Electricity and plumbing sys-tems in poor state, high use of DHW Discomfort due to draughty flats, thermal bridging, poor sound proofing. Poor accessi-bility and little variation in flat sizes Bathrooms, kitchens, common areas need renewal

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 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:	***Delft, the Netherlands:***	***Alingsås, Sweden:***
Concrete structures, load bearing exterior sandwich walls and flat concrete roofs	Load bearing cavity brick walls with suspended wooden floors and pitched wooden roofs	Load bearing concrete structures, wooden studs infill walls and cold attics with a wooden exterior roof.
Rendered façades, thin insulation towards the street, supplementary EIFS towards the backyard. Roofs covered with gravel. Basement not insulated	Exterior side of walls function as brick façades. Supplementary insulated cavities. Tiled roofs. Basement crawl spaces not insulated.	Curtain brick façades changed once, but in poor state. Windows exchanged in the 1980's. Bitumen roof covering. Thin insulation board under floor slabs.
Central heating, fossil gas	Individually heated, fossil gas	Central heating, district heating
Natural ventilation	Natural ventilation	Exhaust ventilation
Individual heating of DHW	Individual heating of DHW	Central heating of DHW

Besides the technical systems of the buildings themselves, local energy systems imply on what technology that is suitable. In Sweden, multifamily dwellings are very often connected to a district heating system (89% of the dwellings were heated that way in 2010 [SCB 2012], but fuel might vary). At an EU level, however, fossil gas is the most common energy carrier, for instant making up 74% of the Dutch households' energy demand in 2009 [Odyssee-Mure 2012].

Technical measures selected within BEEM-UP

Originating from the current building systems and conditions, focus has been set to different measures in the pilots. For replication, measures used at one pilot can appeal to buildings with similar prerequisities.

Building envelope measures

To address the target of decreased energy demand for space heating, thermal performance of the building envelope was enhanced in all pilots, preferably by exterior measures where possible. Windows and entrance doors were exchanged in all projects, and air tightness was seen to to some extent.

Slab on ground structures (Alingsås) are problematic in retrofittings as they can hardly be supplementary insulated on the outside. If interior insulation is applied, thermal bridging through foundation elements and wall structures that penetrate the insulation layer will increase. The same apply to the floor/outer wall connection of suspended floors. Experiences from Alingsås show that the perhaps neglected influence on the ground floor U-value by such measures can be severe.

The Alingsås project exchanged the top layers of the existing sand and concrete structures with an interior insulation of extruded polyisocyanurate (PIR) boards, rigid enough to ensure support for floors. Additional measures were however needed to protect the material from moisture, dirt and chemical impact from the high pH value of the concrete. The U-value and thermal comfort is found to be significantly improved. A supplementary exterior footing insulation has also been suggested to decrease the heat loss through thermal bridging and lower the need for additional heating in bottom floor flats. For these to be passive house flats, the priority to larger family flats with higher heat production on the bottom floor has also been identified in the architectural layout.

For suspended floors, exterior insulation can be applied even though the working space is limited. To decrease the extent of work in the crawl space, the Delft demonstrator chose a solution with layers of reflecting insulation foils hung up in closed sections between the joists from under the floor, with an additional vapour barrier on the ground. Pre-assembly evaluations show that a considerable improvement can be expected in terms of heat loss, thermal comfort and moisture conditions of the wooden floors [Evert Hasselaar, 2013-04-03]. For buildings with a dry, heated bottom floor space below dwellings the need for exterior insulation is less critical as heat losses are lower. In Paris, interior insulation was used in the basement ceiling to prevent heat losses through floors of first floor flats.

The passive house targets in Alingsås called for a U-values to be cut by about half and thermal bridges to be broken by a high rate of insulation, and a very high air tightness to be achieved. As façades needed replacement and the existing wooden frame infill wall was in a poor state, the entire wall was cleared out and rebuilt to ensure quality. This enabled a better work flow than a patchwork methodology. However, the process also meant a complete evacuation of the tenants. On the other hand, the deep renovation enabled additional rentable living space; walls could be moved as formerly indented balconies were included in the living room area. The additional space was used to increase accessibility and standard of bathrooms. In Paris, additional space was also created as the new bow windows for balconies will be moved out to the balconies' edges.

In Paris and Delft where the minimised disturbance of tenants was a major issue, a deep renovation was not possible. As the existing wall structures were in a good state in these projects, only exterior measures were needed. The characteristic brick façades in Delft were cleaned and repaired, and underwent a hydrophobisation. Impregnation can apart from the water protection also improve the thermal performance of a cavity wall if brick are kept drier and thus better insulating [Akram & Hamid, 2010]. At the same time, the architectural expression could be kept. In Alingsås, where the brick façades needed replacement, efforts were made to keep the architecture of the area as a whole. The shape of buildings and courts were maintained as no exterior entrance buildings or alike were allowed, and a ceramic tile material was chosen to replace the brick façade. In the case of Paris, an EIFS supplementary exterior insulation was possible without changing the expression of the original rendered façade. Where needed, high performance insulation can be used not to exceed the allowed dimensions of the building. In Alingsås, being a less dense area, permission was given to increase the building dimensions thus enabling enough traditional insulation material to reach the low U-value required.

Regarding roofs, the pitched roofs of Delft were effectively insulated exteriorly using prefabricated modules of high performance insulation (graphite enhanced EPS). Element joints were sealed and the roofs were quickly completed with battens and roof tiles (tiles were reused where possible). In Alingsås, the attic space was completed with a vapour barrier and the insulation was replaced and increased, and the roof was reinforced. As heat losses through the roof thus decreased, the outer wooden roof was supplementary insulated to avoid moisture problems and ensure the building code RH-level (max 75%).

Building services' measures

In the following Table 5, conditions for energy supply in the buildings after retrofitting are listed. Changes apply to heat supply, HVAC systems and feedback systems (ICT) on energy use.

Table 5 Energy source and installation systems in the pilots after retrofit, to be compared with **Table 4**

Source: WP1	***Paris, France:***	***Delft, the Netherlands:***	***Alingsås, Sweden:***
Heat source	Fossil gas. New central condensing boiler. Central sewage heat recovery	Fossil gas. Option of new condensing boilers and solar collectors per flat	District heating (bio fuelled), heat recovery from outlet air
Heat distribution	Waterborne floor heating, individually controlled per flat	Waterborne system with radiators offered, controlled per radiator	Airborne distribution with waterborne supply to air heaters, controlled per flat
Domestic Hot Water (DHW)	Central system, with a heat pump in combination with sewage heat recovery	Decentralised systems, heated by fossil gas	Central system, district heating. Reducing taps.
Ventilation	Central system, humidity controlled mechanical exhaust system	Natural ventilation	Central system, mechanical supply and exhaust system with heat recovery
Information and Communication Technology	Synco living system; an 11% saving expected. Individual billing of DHW is introduced.	Eneco Toon Display, real time feedback on gas and electricity use	Individual billing and feedback is introduced

Since district heating at a very high rate of renewable energy already was used for heating and DHW in Alingsås, there was no sustainability gain in a change of heating source. Instead, the heating system (airborne distribution) was designed to be fed by hot water instead of electricity. For buildings in cities like Paris and Delft using fossil gas for heating and DHW, there can be an incentive to change energy source from renewable energy, CO_2 or national independency perspective [Daša Majcen, 2013-04-13]. The projects not changing heat source added a heat recovery system (from sewage to DHW in Paris, from outlet to intake air in Alingsås) to decrease the energy demand for heating.

Paris and Alingsås wanted centralised HVAC systems while decentralised systems were more suitable in the Delft buildings. Paris already had a central heat distribution and a ductwork system for natural ventilation, and can easily change the boiler, add heat recovery and exhaust fans for ventilation. In Alingsås, the exhaust ventilation trunking was supplemented with air inlet ductwork and a central plant room with heat recovery. For Delft, some households do not currently have a heat distribution system within their flat, and to get the solar system they therefore need to pay extra for a distribution system and a condensing boiler, while others can simply connect the solar boiler to their existing system. The Paris building goes from individual to central DHW systems. For the Delft buildings however, central systems would not be rational and decentralised systems are kept. Still, the solar boiler offer has been compromised by the wide variety in existing systems, and not every tenant wants to change systems. Nevertheless, this far a 50% of flats have installed the solar heat system.

In Delft, a 30% of tenants have chosen the ICT display system (April 2013), and they are very enthusiastic about the system. The monthly fee is paid by Woonbron during two initial years.

The retrofitting project process

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 can be applied to most retrofitting projects to an overall or deeper extent.

A quality assurance system has been followed in the BEEM-UP approach. In order to achieve the intended performance results, the QA system shall function as a systematic routine and communication tool to ensure that right actions and right responsibility through all stages of retrofitting, commissioning and maintenance phase. 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.

Process-wise, the involvement of tenants has been found to be an important aspect in all three sites and is thoroughly developed within WP5. In the retrofitting process, communication is a key issue. Tenants are informed about actions planned, what's happening and why. Coffee and cookies has been shown to be a useful way to open up the discussion when building owners invite tenants for information meetings. Still, the involvement goes much deeper than bare information. Examples from WP5 are such as workshops and enquires 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.

To anchor the QA system in the organisation is also a question of communication. Apart from the tenants, all performers and key actors of the process need to be involved. For this reason, kickoff meetings have been held in the start of a construction project involving everyone, from building owners to consultants and skilled workers engaged in the project and with an impact on the result. The kickoff 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 kickoff 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 is the retrofitting process itself and the competence and engagement of building owners 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.

Resulting energy savings

With respect to national regulations and the conditions of each site, technical measures and organisations of the demonstration projects have been chosen as described above. In order to make the demonstration useful to replications, the success of demonstrations in terms of energy efficiency is of course the critical result. As concluded in the section National and local requirements, significant reductions in energy use for space heating, DHW and common electricity is demanded to meet national EPBD targets, but also tenants use of tap water and electricity needs to be seen to in order to meet sustainability targets in terms of ecology, economy and social aspects.

In Delft, preliminary results from 2012 show that most flats investigated after building envelope retrofit reach Energy label A. However, there are some uncertain results from initial energy scans and further investigations will be made. Alingsås buildings have so far cut its energy demand by about half, reaching or almost reaching the heat power targets for new buildings using passive house technology, which is very promising for retrofitting. In Paris, retrofitting works have just started and no evaluation is yet possible. The individual billing of heating energy and tap water made a clear difference to the tenants energy use in the pilot building of Alingsås. In Delft, the real time energy display and feedback system of energy billing show so far a possibility of a reduction up to 15% of domestic energy use, according to the supplier Eneco. For France, an 11% reduction is foreseen but ICT systems are not yet installed. Thus the significantly decreased use of energy is possible and of benefit both ecologically and economical to building owners and tenants.

Target groups

To enable replication, demonstration experiences and results need to be spread to influent actors of future retrofitting projects. Possible target groups for the demonstration are found to be such as

- Other building owners interested in retrofitting their buildings and to enable a successful process
- Contraction companies that are to perform these reconstructions, develop new methods and approaches and educate their staff on energy efficient retrofitting

- Architects, structural engineers and MEP designers that can involve experiences drawn in earlier projects in the design of future ones
- The public, tenants and building owners that need showcases and success stories to understand and explore the need of increased energy efficiency in the European building stock in order to ensure a sustainable development and a future good life. A successful demonstration can show that energy efficient retrofitting is not a threat in terms of cost or impaired living comfort, but can mean the opposite, enhancing the comfort and social aspects for the inhabitants involved.
- Finally, governments, national and EU decision makers that need examples of how the EPBD can be targeted by carefully prepared and well performed retrofitting process with well defined goals in terms of sustainability

Conclusions

The three demonstration projects are found to differ in quite many aspects, together showing a much wider representativity on European level than a single example would do. 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. From this demonstration it is clear that there are similarities between countries in what energy aspects to address (space heating, DHW, electricity or energy supply) even though details might vary.

Based on the variations in buildings, organisation and economic models, the choice of targets and hereby the resulting selection of social and technical measures of the BEEM-UP pilots will cover a great variety, from which many individual actions can appeal to replication in future retrofitting projects. Together, experiences from the three pilots and their retrofitting processes respectively as compiled and evaluated within BEEM-UP will hopefully be able to serve as a smorgasbord from which other European building owners can find actions and processes to replicate matching their own situation. The sustainability approach focusing on achieving good dwellings socially, economically and ecologically from a holistic perspective can be replicated as an overall goal of the retrofitting process.

There will be several target groups to benefit from the demonstration, to repeat successes and to avoid mistakes made. To other building owners, the BEEM-UP pioneers can serve as role models whose situation one can identify with. The organisation and involving retrofitting process can be copied at most conditions. Technically, contractors and consultants can earn experience along with the building owners. Last but not least, the pilot projects aim to show to the public, tenants and governments that retrofitting towards energy efficiency is possible, including all aspects of sustainability– ecologically, economically and socially. If the BEEM-UP demonstration objectives are met, an important mile stone is set to initiate the massive renovation of the EU building park needed to fulfil the EPBD targets of 2020 and 2050.

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