BEEM-UP
Building Energy Efficiency for a Massive Market Uptake

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Abstract

BEEM-UP demonstrates the economic, social and technical feasibility of retrofitting initiatives for drastically reducing the energy consumption in existing buildings. The aim is also to use the results to lay the ground for massive market uptake of energy efficient retrofitting.

BEEM-UP are implemented in three sites (France, the Netherlands and Sweden) and incorporate innovative solutions to achieve a 75% reduction in space heat energy use, in addition to reduce the energy demand for hot water and lighting, while ensuring a comfortable and healthy living environment. These ambitious targets are demonstrated through the most economical attractive alternatives for retrofitting and thereby setting the ground for massive market uptake. An absolute condition to succeed is to use integrated design. In integrated design the building owners, industry, designers and energy experts collaborate around the building to reach a higher performance and be more adapted to the tenant needs than if just plugging in separate solutions are used. New concepts have been identified within BEEM-UP that can be replicated in further retrofitting projects.

An ambitious monitoring program to demonstrate the reduction in energy consumption has been accompanying the whole process and will continue over a period of at least two years after the retrofit. This technical monitoring is complemented with a social monitoring, focusing on the involvement and acceptance by the tenants. A whole program is designated to involve the tenants in the retrofit. ICT systems (smart metering and building control) will encourage and support energy savings.

The main challenge is to turn energy reduction in existing buildings into standard option on the market. Going beyond pure demonstration, the aim of BEEM-UP is to develop an exploitation plan based on the results from the project , actively disseminated across Europe, and interact with stakeholders, to create a solid demand for energy reductions by building owners, and make BEEM-UP a model for future retrofits. Before 2020, all retrofit projects in Europe will target ambitious energy reductions: not because it is “compulsory and good”, but because it is the most attractive alternative.

The aim for this paper is to give an overall description of the project aim and content of BEEM-UP. A number of papers covering BEEM-UP related issues in more detail will be presented at the conference, (Martinsson et al 2013), (Hiller et al 2013), (Alexandersson 2013) and (Jacobs et al 2013).

Keywords: Passive house, (Million Homes Program), Energy efficiency, Sustainable Retrofitting, Multi-family housing, Cost-effective Retrofitting

Introduction

The urgency for Europe to transform into a low-carbon economy to meet climate and energy security targets is a fact, (SET Plan, 2009). One of the most cost-effective measures to meet energy reduction targets, as clearly specified in the "European Economic Recovery Plan", is to address the existing building stock (ECOFYS, 2005). Buildings account for 40% of the European energy consumption and one third of the green-house gas emissions. By 2050, the energy consumption in buildings could be cut with an amount corresponding to today's transportation and industrial sectors combined, (WBCSD, 2009) In particular, the state of the European residential building stock contains a tremendous improvement potential. Emissions of greenhouse gases from residential buildings may be cut around 30-50% over the next 40 years, (EP, 2009). However, it requires radical change. Technology advances are being made as the European construction industry is aligning its R&D initiatives with EU policies. Europe has launched several instruments being at the forefront to fight climate change, boost research in construction and solve market failures, such as the Energy Efficiency Action Plan, the EPBD recast, the EU Economic Recovery Plan, SET Plan, and Lead Markets Initiative on Sustainable Construction. Until now, the market has failed to adopt the notion of energy efficient refurbishment on a large scale, and a vast majority of renovations only led to marginal savings in energy consumption. This is particularly true for the residential sector where a "business as usual" scenario not only impedes the competitiveness of European industry, and hinders society from achieving the imperative energy targets, but also turns the access to appropriate home comfort level into an economic issue.

Several key challenges stand in the way of transforming the existing housing stock as desired. First, there is a **lack of easily accessible, cost-effective solutions** for energy efficiency **optimized for renovation purposes**; most State-of-the-Art solutions have been developed and deployed for new-built low energy buildings. Current energy efficiency retrofitting projects therefore tend to turn into **expensive pilots** with customized solutions. Another challenge when refurbishing residential buildings is the little knowledge on how **occupants' accept innovative solutions** and impact the final energy consumption. Finally, building owners and investors **do often not have access to clear data of the concrete value that energy efficiency adds**, while split incentives hinder a full life cycle cost perspective and encourages short-term based income models.

The scope is limited to multi-family, residential buildings with a rental tenure structure, which is representing 18% of the European housing stock (36% in Sweden, 24% in NL, 30% in France). This specific scope allows for a clear interchange of experience throughout the project, and to specifically target the exploitation, at the same time as a great part of the BEEM-UP concept has potential for reproduction also in other types of buildings. The aim with BEEM-UP is to develop a retrofitting model that can be applied to different regions, considering their specific cultural, socioeconomic and climatic aspects. The selected demonstrators have strong similarities and replication potential to central, northern and Eastern Europe because of the similar rental tenure schemes and construction typologies for residential buildings. Southern Europe has typically different proprietary schemes that BEEM-UP will consider in its exploitation model.

Figure 1 Map of pilot sites, and replication potential based on building type and tenure structure.

Objective

The overall objective of BEEM-UP is to develop and demonstrate cost-effective and high performance renovation of existing residential multi-family buildings, drastically reducing the energy consumption: at least 75% reduction in primary energy demand for space heating while ensuring a comfortable and healthy living environment and favoring the integration of renewable energy. The potential of the action is a total energy reduction of 4GWh/year, and 1041 Tons CO_2 reduction per year**.**

Three retrofitting projects in Sweden, the Netherlands and France will demonstrate in the **technical, social and economic** feasibility of the BEEM-UP concept, using this experience to compile an integral **energy efficient refurbishing package**, aimed for **replication throughout the European housing stock**.

Through a close-knit collaboration between key actors in the retrofitting value chain – construction companies, energy efficient solution suppliers, building owners – and leading European research institutes and universities working on energy efficient buildings, BEEM-UP assures that the demonstration targets will be achieved and the resulting concept disseminated across Europe, as a basis for massive market roll-out. Such a roll-out would directly support the European targets of ambitious energy reduction by 2020, while opening up a multi-billion business opportunity for Europe's building sector, while improving the quality of life and cutting the energy bills for European building owners and citizens.

Additionally, BEEM-UP has the following scientific and technical objectives:

- To define, implement and enhance an integral global approach to energy efficient retrofitting, from design to post-occupancy, based on stakeholder involvement and economic viability throughout the process.
- To **optimize advanced** insulation and energy management standard solutions for cost-efficient application in the demonstration projects, and create a **protocol for further development** to allow for direct application in future retrofitting projects.
- To present building owners and investors with **clear economic evidence** of the value of

investments in energy reduction of existing housing and provide decision support tools for **assessing the optimal investment** across the housing stock. The target is to show at least a 20% higher terminal value after 30 years compared to a minimum standard renovation.

- **To set the basis for massive replication** of the demonstrated concept across Europe, through an appropriate dissemination and exploitation plan, by compiling the key deliverables of BEEM-UP into an **energy efficient refurbishment package** that is ready to deploy in multi-family housing with a rental tenure structure across Europe (18% of housing stock, some 35M dwellings).
- To **strengthen the stakeholder's** ability to support the energy reduction goals of EU's energy and climate policy and when applicable increase their capacity to manage the necessary transformation to meet the requirements of European building policy.

Method

Work packages

The BEEM-UP approach is based on gradual integration of the building blocks that set the foundation for massive uptake: demonstration and development of an adaptable integrated design process (WP1); innovation to tailor effective solutions for the sites and further industrial application (WP4); realization of retrofitting (WP2) and detailed monitoring (WP3); understanding of occupant behavior for actual energy savings and increased social value (WP5); and exploitation based on economic incentives for building owners and policy makers to take action (WP6). These pieces all come together in an energy efficient refurbishment package compiled at the end as a guideline for replication of the BEEM-UP concept at further sites across Europe. Continuous, coherent, dissemination and training (WP7) across Europe aim to further increase the impact. The connections between the different work-packages are shown in Figure 2.

<u>Technical feasibility (WP1-4)</u>
At the demonstration sites, a clearly defined integrated design approach, together with specific optimization of integrated solutions, is deployed to target the technical challenge. Local teams (building owner, design team and local solution suppliers), industry and energy experts collaborate to integrate, adapt and optimize the most adequate solutions for achieving drastic energy savings in the retrofitting projects. Computer simulation tools are utilized throughout the design to ensure the energy-economic optimization of all key decisions. Industrial partners also collaborate on innovation to technically advance the performance specifically of the building envelope and energy management systems, always with focus on cost-effective application as well as replication.

<u>Social feasibility (WP5)</u>
To target the need for tenant understanding, each site has developed a targeted social action plan to involve the tenants from the start of the retrofitting, and ensure clear communication at all stages. Through the process, research will aim to understand the motivation and needs of the tenants to include these in the retrofitting design and the plans for further reproduction. We also expect to advance the understanding of tenant interaction with energy efficient solutions. The process will be tuned throughout the project, and shaped into a set of guidelines for tenant interaction.

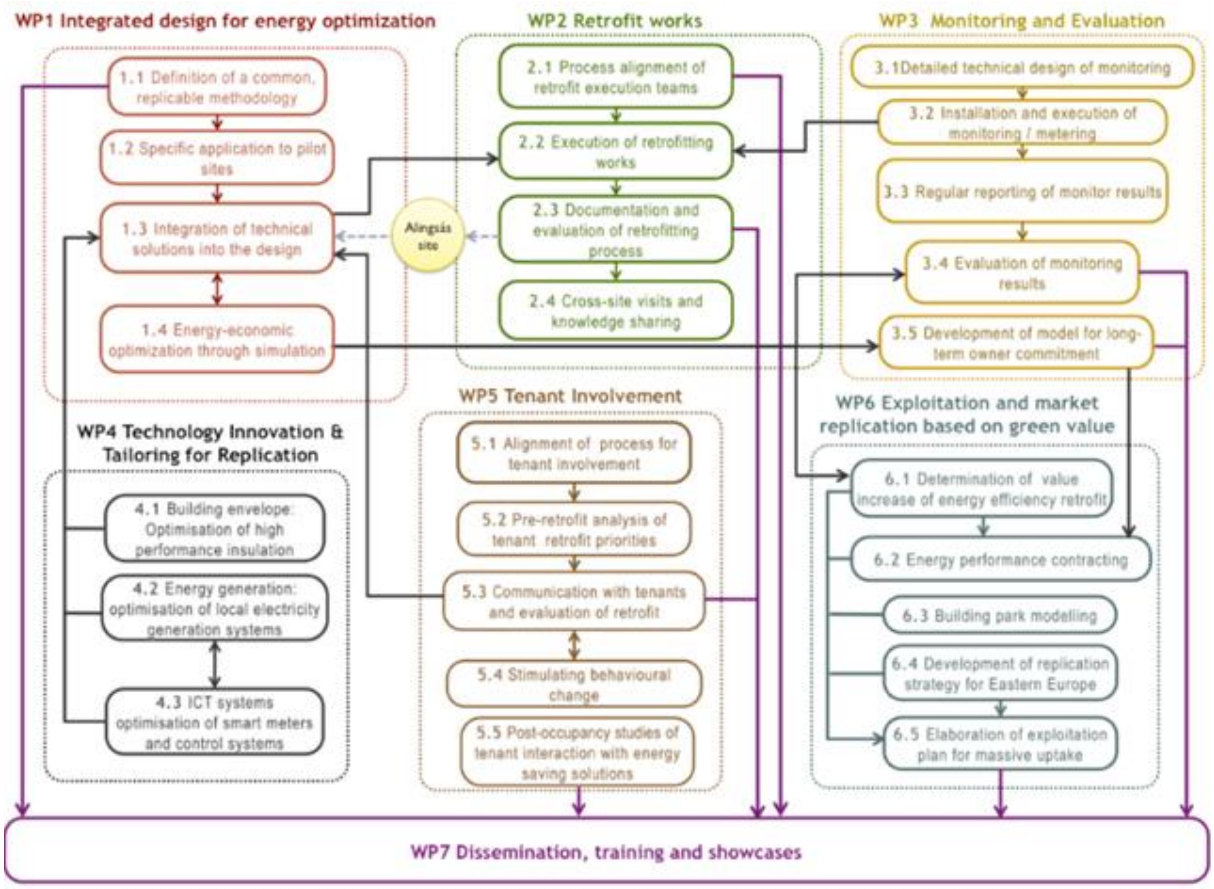

Figure 2 Work packages and tasks within the BEEM-UP project.

Economic feasibility (WP6)
From the initial steps of BEEM-UP, the economic feasibility has been a keystone of the three retrofitting projects. Based on simulations results and calculations for the return of investment, the building owners are convinced about the economic potential of BEEM-UP. The economic evidence for the total profitability of energy efficiency investments, including green value, are gathered throughout the demonstration and backed up by academic expertise. Financing models are developed that capitalize on this evidence. All the evidence and models feed straight in to the exploitation plan of BEEM-UP for massive market uptake.

Consortium

BEEM-UP brings together a consortium of complementary background and expertise to demonstrate the technical, social and economic feasibility of drastically reducing the energy consumption in existing residential multi-family buildings at three sites in Sweden, France and the Netherlands, and replicate the developed concept in the European housing stock. To address the difference in local conditions, which limit the direct replication of a fixed technical concept, BEEM-UP deals with both the complete retrofitting process applied to three sites and the way it can be adapted to any retrofitting project across Europe, always with the aim to optimize energy efficiency and costs. The partners involved are shown in Figure 3.

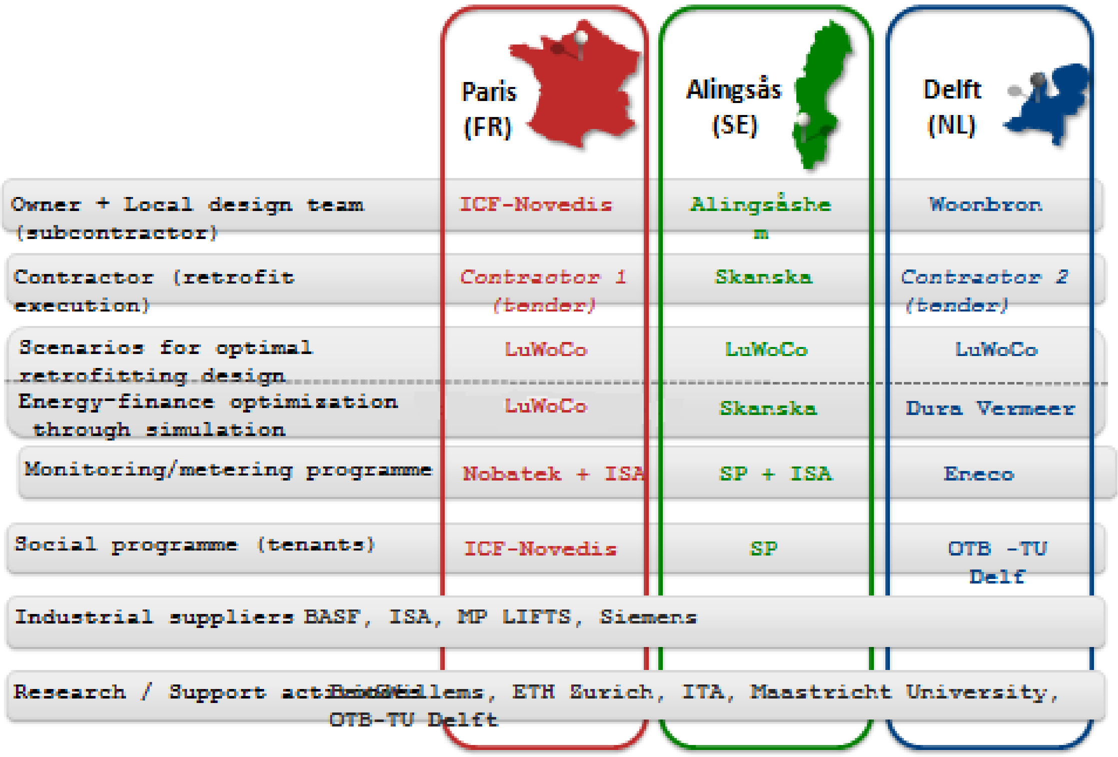

Figure 3 Partners involved in the three demo sites.

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.

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.

Alingsås, Sweden:

Eight 2-4 stories multifamily buil-dings 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.

Figure 4: Short facts on the demo sites.

Results

As the BEEM-UP project is more than half way through, a number of promising results can be shown. The remaining work is to improve, refine and communicate the results.

Integrated design (WP1)

A common replicable methodology for assessing retrofitting alternatives, using key performance indicators for three dimensions, social environment and economical has been developed. Development of specific retrofitting scenarios based on existing analysis of the buildings and dialogue with the building owners has been evaluated taking into account energy savings and life cycle costs. The process is show schematically in Figure 5.

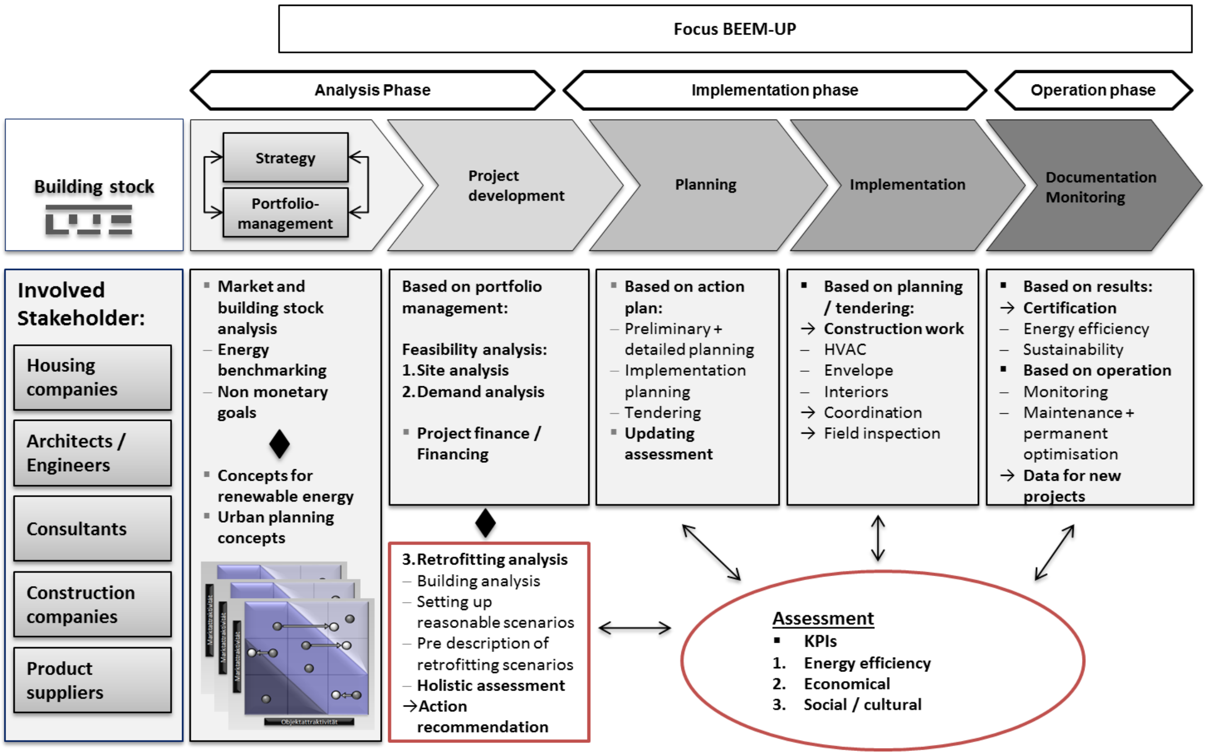

Figure 5 Retrofitting process with phases.

Retrofit works (WP2)

The method has been used for all three demo sites. The visualization of the results is very easy to interpret by building owners about to make decisions. For example, results have shown a small increase in investment costs might have a great impact on energy savings, (Jacobs and Reuter, 2013).

The quality aspect has been in focus and has been addressed at kick-off meetings for all involved within the building process. Thus everybody involved knew the goals of the projects enabling them to perform at their best. The process in the different demo sites has been thoroughly documented by photos, videos and interviews of e.g. site managers and skilled workers. This material will form the basis of communication and illustration of the results of BEEM-UP in order to enhance the low energy retrofitting massive market uptake. During the process, development of the demonstrators is communicated through the website with monthly updates for each of the three demo sites (www.beem-up.eu).

In Alingsås half of the buildings are completed and the tenants have moved back. In Delft work is going as planned and the main part of the work is completed. In Paris the construction work has just begun after a delay and will continue throughout the year.

A number of cross site visits promotes knowledge sharing between people involved in the demo projects. These interactions have been fruitful and greatly appreciated for the learning process.

Monitoring results (WP3)

The first step was to create a common set of guidelines for the monitoring programme. Based on this a detailed technical design for the monitoring applicable at the three demo sites was produced.

The monitoring equipment was installed in a reference building in Alingsås. In order to access performance the retrofitting measures considering the whole refurbishment and work process implemented within BEEMUP. A number of parameters are monitored, e.g. continuous measurements of indoor and outdoor temperature and RH, surface temperature, CO_2, DHW, electricity and district heating. Notable is that since the start of the project the market for monitoring has greatly advanced towards cheaper yet more advanced equipment. At the same time the user interfaces have greatly improved.

Technology innovation (WP 4)

Firstly, performance criteria were listed for the different sites and ideas were tested. A total of 19 mock-ups of infill wall, solid wall/ETICS, cavity walls, slab on ground, crawl space and roof have been constructed to test the applicability to the different sites. High performance insulation was used in many of the mock-ups. The mock-ups covered both very innovative designs using front line high performance insulation and known technology used in innovative ways.

With origin in this work package a new wall was developed for the Alingsås project. This work has been presented in (Martinsson and Tengberg, 2012) and (Eriksson et al, 2011). The onsite performance of the wall hopefully will be further investigated with support from the Swedish Energy Agency.

The focus of the energy control system and electricity generation has resulted in a suggested PV solution for Alingsås. An early idea of electricity generating elevators did not prove to be economically viable as the running time of the elevators was too low. Instead, the most cost efficient solution proved to be low energy hydraulic elevators with several levels of standby functions. Preliminary results show that the electricity use for elevators is slightly more than 1 kWh/m^2, year.

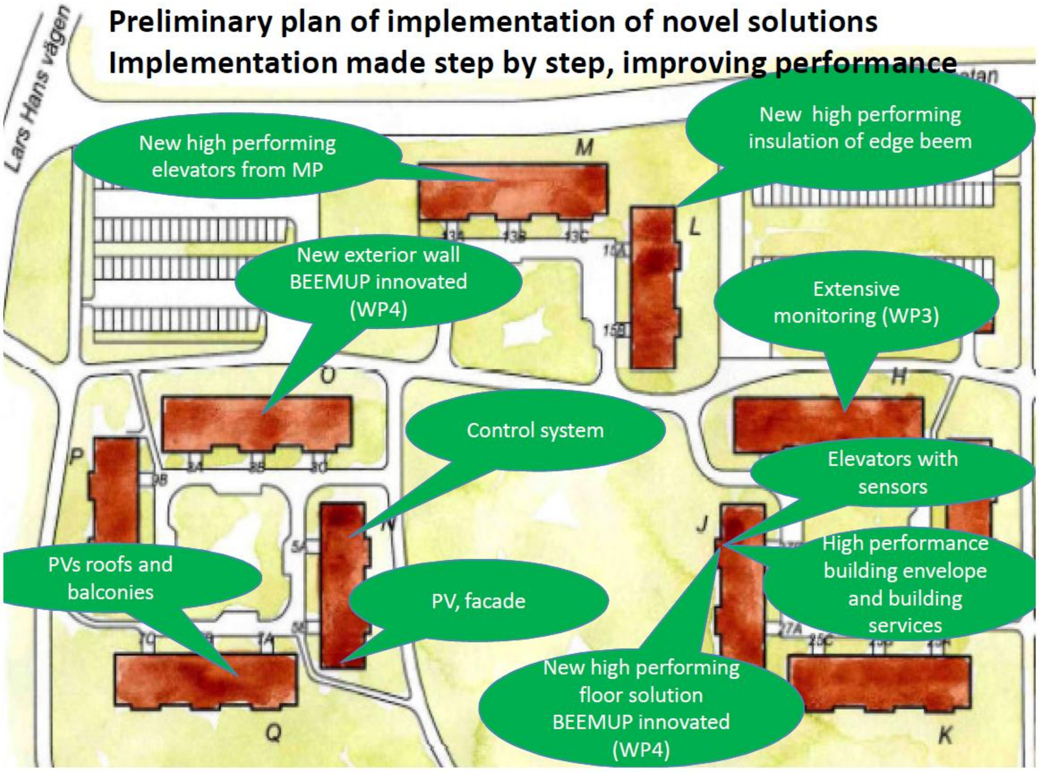

Figure 6 The retrofitted buildings in Alingsås together with suggested measures.

In Paris a system for heat recovery of gray water will be installed and evaluated.

In Delft smart metering is in focus, developing a suitable interface for the target groups.

Tenant involvement (WP5)

From a protocol on tenant involvement explaining why tenant involvement is important as well as strategies for achieving a good tenant involvement. Pre-retrofit analysis has been carried out in the three sites. The building owner Alingsåshem has involved the tenants directly and indirectly. Indirectly by investigating household lifestyle profiles of the tenants and by looking into the tenants' service notification. This is a way to increase the understanding of why different people. The tenants have also been approached directly by one way information meetings and by two way communication workshops (held with the Swedish Union of Tenants). Meeting places created by the open houses in the show apartment have been important in order to establish a communication relationship, both between Alingsåshem and the tenants and between the tenants themselves.

In Delft, Woonbron´s communication has been done with a tenant feedback group. Problems with the windows were the starting point but the work has been further developed. The feedback group is used to develop a shared opinion on the improvements needed and to ensure that costs and measures are in line with the needs of the tenants. Furthermore, open house sessions have been held in order for people to inform themselves about retrofitting and to have the possibility to ask questions.

In Paris ICF have built trust with tenants over the last year by meetings, workshops and individual interviews with the tenants. The activities and the long preparations regarding the continuous interaction with tenants are a new way of working which is a result from the BEEM-UP project.

The work on tenant involvement is presented in more detail in (Hiller et. al, 2013).

Exploitation and market replication (WP6)

Evaluating the average expected performance of each retrofit package and estimating the risk and uncertainty behind the project, will enable economic actors to make more informed operational decision in the future. So far, data has been collected for the empirical models.

A comparison between the three demo sites and the different prerequisites are presented in (Martinsson and Zietara, 2013).

Discussion

An overall observation is that success of such a large collaboration project is highly dependent on dedication of partners. A complication is the long preparation time of an EU-project. There is a difference in time schedule between the different demo sites. The decision of the building owners on investing in extensive retrofitting works is dependent on many factors, apart from the EU-project. Delays can be caused by unexpected conditions appearing during the retrofitting process. Sometimes this cannot be foreseen.

As it is a demo project, the technical solutions are not decided but evolve during the project. Some of the expected solutions with innovative techniques have proven not to be cost-effective. An example of this is electricity generating elevators proving to be inefficient with low frequency in use. The iterative process in Alingsås, together with an outstanding commitment from the people involved, has proven to enable the efficient use of innovative solutions. A key issue to commitment is sharing of information at the building site. Benefits from iterations, together with long-term financial models have proven that high performing energy efficient solution can be applied. The strong partnership within the project has also enabled new solutions to evolve, both within the project and in cooperation with material suppliers. By using both skilled workers and theoretical expertise in the improvement process, cost-savings and performance improvement have been possible together with other improvements, e.g. on the ergonomic situation at site. The successively improved wall design is a good example of involvement of suppliers and skilled workers. There are also examples of by calling for a specific performance; suppliers have been able to develop better products for low energy market. An example of this is a self-grouting nail without thermoset plastic introduced at Alingsås.

Conclusions

- Collaboration between stakeholders in holistic integrated design is crucial to reach higher performance.
- By implementing an innovative approach, it is possible to go beyond a **75% reduction in space heat energy demand.**
- A success factor has been to identify and further develop new concepts that can be replicated in further retrofit projects.
- Based on experience from the three demo projects an exploitation plan based on green value will be developed and actively disseminated across Europe.

Acknowledgement

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