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**JEROEN VRIJDEERS<sup>1</sup>**  
**SANDRINE HERINCKX<sup>1</sup>**  
**ERWIN MLECNIK<sup>2,3</sup>**  
**IRENA KONDRATENKO<sup>2</sup>**  
**JOHAN CRE<sup>2</sup>**

<sup>1</sup>**Belgan Building Research Institute (BBRI)**  
 Lombardstraat 42  
 B-1000 Brussels  
 Belgium  
 Tel: + 32 2 655 77 11  
 E-mail: Jeroen.Vrijders@bbri.be  
 www.bbri.be

<sup>2</sup>**Passiefhuis-Platform vzw**  
 Gitschotellei 138  
 B-2600 Berchem  
 Belgium  
 Tel: +32 3 235 02 81  
 Fax: +32 3 271 03 59  
 E-mail: erwin.mlecnik@passiefhuisplatform.be  
 www.passiefhuisplatform.be

<sup>3</sup>**OTB, Delft University of Technology**  
 P.O. Box 5030  
 NL-2600 GA Delft

## Execution of very low energy renovation through an integrated approach and application of new technology

### ABSTRACT

*From the previous LEHR-project, it became clear that many retrofit projects are executed in a very fragmented way: many actors do a certain part of the works, without cooperation or coordination. Sometimes, there is a lack of attention for works that*

*have been executed already, or the works that have to be executed afterwards are not kept in mind. This is however very important, especially when striving for nearly zero energy buildings in housing.*

*It is desirable that every activity executed in a renovation, is integrated in a global concept, and thus takes into account the works executed earlier and afterwards in the process chain.*

*The presented research was executed during the One-Stop-Shop-project. It maps these interactions for thorough, nearly-zero-energy, retrofit projects, using a structured approach (matrix), a process analysis and contacts with frontrunners in the field. An overview is given of the most important and critical attention points during design and execution, when different actors intervene in the same project. This overview allows for the development of solutions. These can be a more integrated execution of the works and/or the application of innovative technology. A selection of solutions is presented.*

### 1. INTRODUCTION – THE ONE STOP SHOP PROJECT

European and national ambitions to become an energy efficient society also address the built environment. In first instance, focus is put on the construction of new buildings. For instance, new houses have to comply with limits set on characteristic energy consumption and minimal insulation levels. These limits become stricter throughout the years. The EU has set its ambition level on new ‘nearly zero energy buildings’ around the year 2020.

However, it becomes more and more clear that, in order to achieve the energy saving targets set on mid-long (2020) and long (2050) term, not only new buildings should be addressed, but also the vast existing building stock should be transformed. It will be necessary to retrofit a considerable part of the existing building stock towards much lower energy consumption.

This means on the one hand that an increase in renovation activity is needed. On the other hand, given the ambitions set towards passive house standards, zero-energy buildings, CO<sub>2</sub>-neutral buildings, .... also more thorough, deep, energy-saving renovations will be necessary. A new market of advanced, very energy efficient retrofits is emerging [1].

Looking at the residential sector, in most European countries, only a limited number of demonstration projects of advanced, deep renovations of houses exist. These projects are typically supported by subsidies, and executed by SMEs that can be considered frontrunners on the market. A previous Belgian research project, LEHR (Low Energy Housing Retrofit, [www.lehr.be](http://www.lehr.be)) documented the existing Belgian examples. From the LEHR project, some conclusions were drawn towards existing barriers and problems considering the upscaling of the advanced renovation practice towards a larger audience [2].

Further, house owners lack the possibility to collect all necessary information to decide on a renovation project in a structured, easily accessible manner.

Owners have to ‘patch’ a lot of different information sources together, like existing cases, contacts with building companies, quality assurance possibilities, financial support opportunities, ....

On the other hand, the existing projects demonstrated the fragmentation of the current renovation process. Mostly, a renovation project is executed by many SMEs that do a certain part of the measures, causing problems in terms of communication, interaction and execution of the works. This also has to do with the generally phased approach of a renovation project. Due to budgetary constraints, individual measures are executed consecutively throughout several years, and the consistency between the measures is not always assured.

The One Stop Shop project, funded by IWT within the EU EracoBuild programme, addresses these challenges. On the demand side, a concept for a ‘One Stop Shop’ platform is being developed, that should help house owners by guiding them through the renovation process. It should include elements to find all information necessary for a thorough retrofit in one single place, and enable a direct contact with specialized companies or company clusters offering such holistic renovations.

On the supply side, the platform should also help contractors to offer their services. An important part of the project is aimed at ‘clustering’ the already existing frontrunners in ambitious renovation, which are often small SMEs offering specialised solutions for a part of the project, in order to allow them to offer the ‘integral ambitious renovation approach’ on the One Stop Shop platform. Therefore, a lot of attention goes to the development of cooperation and interaction between specialised contractors on a more strategic, ‘business’ level, eventually combined with other actors in the supply chain, like designers, advisors, ....

Besides the ‘strategic’ work on clustering, it is clear that also ‘in the field’, a need for better communication and cooperation exists. Especially in striving for nearly zero energy buildings, aspects like air tightness, thermal bridges, correct dimensioning of ventilation and heating become very important. When executing a certain task, it is possible that it disturbs work already done; for example destroying the air tightness layer. On the other hand, certain tasks may lead to problems further on (not foreseeing future connections) or can already during their execution facilitate future renovation tasks.

This means that every activity executed during the renovation process, should take into account the work already executed and the current situation on the one hand, and also keep in mind tasks that will be executed later on in the process. All tasks should fit into an integrated, global concept.

## 2. OBJECTIVES & METHODOLOGY

The general objective of the One Stop Shop project – optimisation of the fragmented renovation process, which requires an ‘integrated, holistic approach’ – is translated in this part of the research to the mapping of the points of interest and interactions between the different professionals in the renovation project. In first instance a methodology to create this list of ‘potential problems’ or rather ‘interactions’ was established. The elaborated list of points of interest then serves as a basis for solution development.

The first application of the map is the improvement of communication and creation of more awareness amongst contractors. By calling the problems ‘by name’, they become debatable, and clear agreements on responsibilities and ways of execution can be made. Too often, a contractor performing a small task in a global approach is unaware of the influence his work can have on the work of others. He only takes responsibility for his own work, while neglecting the connection with other parts of the work. In order to have a basis for discussion and mutual agreement between the different executing actors, the information will be presented in a graphical interface (see further). This also allows to link directly to existing guidance on good execution techniques (e.g. Technical Recommendations of BBRI, examples from the demonstration projects, ...) in order to improve the practical knowledge and skills of the contractors. Another important aspect is the development or implementation of new, innovative solutions for some of the potential interactions. More and more European product developers and manufacturers come up with new solutions in order to improve the current building and renovation practice. This can be in terms of improving performance of the products or creating totally new solutions, but in the view of the aspects focused on in this text, more interesting are the ‘integrated product’ solutions, that allow for execution of different tasks at once.

Finally, a last possible application of the ‘interactions map’ can be found in quality control or assurance. The basis of quality is of course the good execution of the tasks on their own (knowledge, skills, procedures), but as explained, a good project ensures that the ‘overlaps’ between the tasks are well managed and executed as well.

In order to map the interactions in the deep renovation process, the following steps were undertaken.

The main part of the work consisted in the creation of a ‘matrix’. This matrix contains in both directions (horizontal & vertical) the different ‘actions’ to be undertaken in a thorough renovation process, structured by ‘building components’: foundations, floors, external walls, windows & doors, roof, installations; each one split up in more detailed renovation tasks (not shown on the figure). This results in a map, where all renovation tasks can be connected to each

other, in two directions. The theoretical process is explained in Figure 1. Point A shows the situation where the new windows and doors are installed before the facade is renovated (say insulated). In this case we look at the (horizontal) line ‘windows’ and look forward to the work listed in the columns (eg. external wall - facade insulation): when installing the windows, one should think ahead of the connections with the future insulation. When insulating the facade, it is clear that there are connections with the already installed windows and doors. We look at the column ‘facade insulation’ (vertical) to ‘check the current situation’. Point B can be interpreted following the same logic: when insulating the roof and installing the air tightness layer, one should give consideration to potential future installations that will need a pass through the layers (eg. ventilation, solar installations), in the other direction, when placing installations, the contractor should be aware of the insulation and the airtight layer in place, and respect them during execution of his work.

		Future/Current tasks				
		...	External wall	Roof	Windows & doors	Installations
Current/Past tasks	...					
	External wall					
	Roof					B
	Windows & doors		A			
	Installations					

FIGURE 1: MATRIX TO MAP INTERACTIONS IN RENOVATION

		Future/Current tasks				
		...	External wall	Roof	Windows & doors	Installations
Current/Past tasks	...					
	External wall					
Insulating roof with eye on FUTURE works		Connection for future façade insulation	Interface flat roof – inclined roof insulation	Foresee connection points for PV-panels	Resistance to future lightning spots	
Current/Past tasks	Windows & doors Installations					

FIGURE 2.A: EXAMPLE OF POINTS OF INTEREST FOR INSULATING A ROOF – LOOKING AHEAD

Figure 2 shows an example of attention points for installing roof insulation with respect to the existing situation and the future works.

		CURRENT CONDITION		
		External wall	Roof	Windows & doors
Current/Past tasks	External wall			
	Roof			
	Windows & doors			
	Installations			

Insulating roof vs CURRENT CONDITION

Foundations ok?

Connection to existing insulation of the wall (thermal bridge)

Potential frost damage – larger temperature cycles in roof tiles

FIGURE 2.B: EXAMPLE OF ATTENTION POINTS FOR INSULATING A ROOF - LOOKING BACK

### 3. MAPPED INTERACTIONS

This way of working allows to create a theoretical overview of potential interactions and problems during execution of the works. In a second phase, the theoretical basis is checked with the current practice in the Belgian field. At the time of writing this paper, the following steps were planned:

- Follow-up on real projects to evaluate if the executers are aware of the possible links with other aspects and to identify missing aspects.
- Feedback from contractors and planners through a workshop. This workshop also forms a part of the ‘clustering’ activities within the One Stop Shop project. By letting the different contractors talk to each other on the point where they interact, a first awareness is created, as well as insight in potential solutions.

The current matrix is 28 rows by 28 columns (= the retrofit activities) and contains 135 cells with one or more attention points or potential overlaps. Looking at the content, the attention points can be grouped in some general categories

- Air/vapour/water tightness: Where different elements of the envelope come together, the interface between the elements is

a critical point, e.g. when installing windows in an insulated facade, or the place where a flat roof construction and a tilted roof construction connect.

- Once the air tight layer is installed, a second series of potential interactions consists in the installation of heating, ventilation, ... that sometimes requires to 'penetrate' and thus destroy a part of the air/vapour barrier.
- Continuity of the insulation layer: the envelope also performs an insulating function, and in order to avoid thermal bridges, the insulating layer should be continuous or the thermal bridge should be remediated. Attention points here can be the provision of potential connections, e.g. when first insulating the inclined roof, make sure that external facade insulation can be connected to it; or to ensure a correct placement of the windows in an insulated facade.
- Dimensioning of installations in function of the (final) envelope. This is more of a planning and final design issue. For example, when insulating the envelope, it is very important that the heating installation is fit to work in the final conditions. Replacing the heating boiler first, will cause an overdimensioning of the power, when the final situation is not kept in mind. On the other hand, when improving air tightness, it is very important that also controlled ventilation is installed, in order to avoid all kinds of moisture problems.

The matrix also contains other aspects, such as influence on the integrity of the building (placing solar panels on a flat roof can cause structural challenges, and also cause damage to the sealing roofing layer or create a thermal bridge through the insulation), and remediation of moisture problems (in walls) before undertaking insulation or finishing works.

#### 4. TOWARDS IMPROVEMENT OF THE PRACTICE

Based on the interactions map, different solutions or improvements can be proposed. First of all, a good execution should be embedded in a good and proper global planning and design. When it is clear that all tasks fit within a holistic project, they can be prepared and executed as such. This also implies a good communication and task description from the architect towards the

contractors. Related to the good planning is also the importance of commissioning. When the quality of execution is checked during and after finishing the project, problems can be revealed in an early stage, and can be remediated. The advantage of a 'holistic project concept' is clear: the different aspects and elements can be tuned to fit in the whole building design, and can be controlled as such.

In line with the general objectives of the One Stop Shop project, a graphical representation of the interactions is developed. A more accessible, easy to use interface is created, in order to facilitate communication towards the target audience. A 3D representation of a retrofitted house is used as model, in which all the relevant activities can be selected. When clicking on a task, the model



FIGURE 3: GRAPHICAL INTERFACE OF THE INTERACTIONS MODEL

shows the related interactions and potential problems. This way of presenting information allows for a direct approach towards the different contractors with their own speciality, and can form the basis for better communication and better understanding between the intervenants.

When the points of interest are shown, as in the Figure 3 above, a logical next step is to provide links to existing information on good and best practice solutions, such as:

- BBRI's Technical Notes and Technical Fiches
- Catalogue of thermal bridge solutions
- Guidelines for better ventilation
- Best practice examples from the case studies
- ...

Besides the link with the existing good or best practice solutions, manufacturers also develop new products and solutions for execution. Part of the work within the One Stop Shop project was dedicated to draw up an inventory of innovative products and execution techniques, especially dealing with ambitious energy renovation. The approach within the project was to collect the information on innovative products in a 'product catalogue', with a one page form per product, containing a general description, availability on the market, advantages and possible limitations and weaknesses, followed by references to the actual manufacturers, exemplary projects where the product is applied, more technical information, ....

This catalogue has the objective to demonstrate the newest possibilities available or emerging on the market, and 'trigger' the thoughts and interest of contractors and designers, and as such stimulating innovation in the practice of execution and design. The catalogue contains a first part on the building envelope and a second part on installations, each one further divided in different categories (walls, windows & doors, ...; heating, cooling, ...). A Belgian based search (also looking abroad), complemented with input from the other European One Stop Shop partners, resulted in a catalogue containing about 40 products and execution techniques for very low energy retrofit. The products can be categorized according to some basic characteristics:

**Improved performance / new concepts:** These are new products, that allow to fulfil a certain function in a more performing or alternative way, or tackle existing problems when using traditional products.

- **Vacuum Insulation Panels:** high insulation level with limited thickness, allowing insulation without room space loss or in small spaces.
- **Aerogel products:** new insulation material that can be applied as insulation and in glazing and is less prone to side-effects and perforation than Vacuum Insulation.

- Double glazing with heat mirror, resulting in highly insulating windows, without the extra weight of the triple glazing.
- Single room heat recovery ventilation unit, allowing for controlled ventilation in rooms that are difficult to integrate in the whole building ventilation concept.
- Internal insulation with moisture control layer, tackling part of the risk of moisture problems with internal insulation.

**Improved execution:** Some 'assisting' products are on the market, or alternative solutions for execution are being developed, in order to improve the situation on site.

- Prefabricated facade elements, ensure a quick execution, and already integrate several functions (insulation, air tightness, windows, ...).
- Passive house windows with integrated air/vapour barrier, allowing a more easy connection to the wall's air/vapour barrier.
- Wireless batteryless sensors & switches, allowing installation and steering of components (lighting) without much destructive work to place the wiring.
- WHISCERS-system, which stands for Whole House In-Situ Carbon Energy Reduction Solution, is being developed in the UK and is an automated measuring, dimensioning and cutting technique for internal insulation to be placed directly, while the owners stay in their house.
- Clips for window installation before external insulation, allow for the window to be placed in line with the external insulation, and thus not interrupt the insulation layer

**Integration of functions:** instead of combining elements on the site, the different renovation aspects are integrated in prefabricated modules or one product.

- Prefabricated modules (roof or whole storey) that fulfil a structural and insulating function.

- Multifunctional facade systems, integrating also water management systems, or solar panels, or other techniques etc.
- Triple glazed window with integrated solar screen, which reduces the number of components to be installed separately and to be coupled afterwards.

## 5. CONCLUSIONS

The One Stop Shop project aims at upscaling holistic, deep renovation of houses and eliminating existing barriers like lack of coordination or cooperation and unsatisfied clients. This is approached by providing a platform for house owners allowing them to decide, and by organising the supply side (contractors) in ‘clusters’ and develop new business models to offer the specialised integral renovation projects.

This paper describes the development of an ‘interactions map’ in a deep retrofit process, to improve the current situation on the site. The matrix, allowing to ‘look back’ in order to preserve the current condition and to ‘look forward’ to foresee future renovation tasks, serves as a basis for solution development. Solutions can be found in an integral design and better quality control on the one hand. On the other hand, documenting the potential problems during interactions allows for a better communication and awareness between the executors, and the directed development and search for solutions. These solutions can be new products or systems, new execution techniques, or integration of functions in modules or services.

The information gathered will be used in the project’s communication towards the target audience, in order to improve uptake of innovation, as well in improving execution as the development of in business models.

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## REFERENCES

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