

Co₂olBricks



**Energetic refurbishment
of historic buildings
in the Baltic Sea Region**

Interim Brochure

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*Värtan Gas Works area in Stockholm.
Photo: Tomas Örn, The Stockholm City
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Dear Reader,



*Frank P. Hesse;
Head of Department for
Heritage Preservation,
Hamburg*

Heritage preservation and climate protection have long been seen as two contradictory aspects that are almost impossible to combine. The reason is that, up to now, the technical discussion has been driven by the Energy Performance Building Directive of the EU, which requires certain energy efficiency standards. It was propagated that the easiest and cheapest way to save energy in buildings is to insulate the walls from the outside.

Of course, the listed buildings are excluded from the obligation to meet certain energy standards, but they shouldn't be exempted at all from energy efficiency measures for two reasons: First of all, they constitute a relevant part of the building stock in the Baltic Sea Region. Listed buildings account for up to 8 % in some countries, and even 13 % in Denmark. On the other hand, economical aspects become more and more relevant as rising energy costs force owners of listed residential buildings to invest in energy efficiency to stay competitive. Otherwise these listed buildings would be in danger of being lost.

This situation produces, from a heritage preservationist's point of view, a set of needs, like the growth of broad awareness and the increase of all stakeholders' know-how. It is very important for us to be able to show and explain alternatives to common methods like the insulation of outer walls, especially for daily, practical work with architects and owners.

With this background in mind, we initiated Co₂olBricks to find more intelligent solutions to overcome the conflicts between heritage preservation and climate protection. Now that we're in the middle of the project, we can already state the common opinion that every single energetic refurbishment needs an individual and detailed investigation of the specifications before one can decide which technical solutions are suitable. Until now, many solutions have been identified and discussed within the project, and have been spread by numerous events in every partner country and by the first publications; the findings and conclusions will go into our educational material for planners and craftsmen. On the political level, we are informing the politicians who make the heritage preservation and climate protection laws.

With this interim brochure, Co₂olBricks presents the current state of discussion. We will advance this process with our upcoming activities, in particular the pilot and research projects.

Eventually I am sure that the whole discussion around these issues of energetic refurbishment of historic buildings will also have a broad impact on unlisted buildings, which must not disappear under a thick layer of rigid foam boards, because they form the faces of our European cities.

Frank P. Hesse

Head of Department for Heritage Preservation, Hamburg

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› The main goal of Co₂olBricks is to identify measures by which the heat energy consumption, and hence the CO₂ emissions, of historic brick buildings can be reduced without destroying their historic value. ‹

Introduction

The Co₂olBricks project is already halfway through and we can look back on intensive work, fruitful discussions and the first practical outputs.

But please let me start from the beginning: Financed by the European Union through the Interreg Baltic Sea Region Programme 2007 – 2013, the Co₂olBricks project started its work at the beginning of 2011. The main goal of Co₂olBricks is to identify measures by which the heat energy consumption, and hence the CO₂ emissions, of historic brick buildings can be reduced without destroying their historic value, especially the value of their external brick facades.



*Jan Prahm;
Project Coordinator,
Co₂olBricks*

For this purpose, 18 partners from nine countries with ten languages came together to commonly investigate various technical solutions, the judicial and financial obstacles involved in energy efficiency measures of historic buildings and how to improve the education of craftsmen, architects and engineers in this field. The partnership consists of national and municipal heritage protection departments, universities, heritage protection organisations, vocational training institutions and energy agencies.

The most important advantage of this transnational cooperation was for the project partners to learn that on the one hand, all countries have a great interest in preserving their historic buildings and that all are interested in reducing their energy consumption, but that on the other hand, the knowledge about possible solutions is not on the same level in the various countries. It has to be noted, however, that in all countries there is always a high interest in the educational and informational events on the refurbishment of energy efficiency of historic buildings. This means that Co₂olBricks is meeting an urgent demand for information.

This was done up to now through six project partner meetings and public seminars, complemented by around 20 information events and seminars on these issues, organised by the project partners in the participating countries. Co₂olBricks consequently reached a critical mass of stakeholders who became aware of the problem and the possible solutions of increasing energy efficiency in historic brick buildings.

With this interim brochure, we want give an overview of the results of the project work that have already been gained, as well as a forecast of the activities coming up before the end of project in December 2013. As the projects' work is divided into the work packages "political development",

“technical solutions” and “education and economic promotion”, the first chapter of this brochure shows the interdependencies of these topics. In Chapter 2, a practical case from Denmark shows an example of an energetic refurbishment process on a historic site. The current status on the energetic refurbishment of historic buildings in the Baltic Sea Region was compiled in baseline studies for each of the three work packages; Chapter 3 contains the main findings of these publications. The last chapter gives an update about the current and planned activities and results that can be expected from the work done by Co₂olBricks. In the annexes, we give some additional information about contact persons or organisations, as well as extant guidelines, documentations and other useful publications in the field of energetic refurbishments of historic buildings.

Hopefully this interim brochure will give you fruitful information. We would be happy to receive your feedback and contributions so that we can come to better solutions for energetic refurbishments of historic buildings.

Jan Prahm

Project Coordinator, Co₂olBricks

1. Interdependencies between technical, legal and educational issues relating to energetic refurbishment of historic buildings

The energetic refurbishment of historic buildings affects a series of different aspects of a legal as well as a technical nature, but also concerns questions about the specific qualifications of the participants. Therefore, Co₂olBricks has defined the three work packages “political development”, “technical solutions” and “education and economic promotion”, which work on the specification of each of these themes.

Because these three themes always intertwine with one another in practice, however, the interdependencies between the technical alternatives, the laws concerning the protection of historic buildings, the climate protection and energy-saving legislation, the variety of funding possibilities and the qualifications of the participants should be illustrated in the following section.

From the point of view of a building owner who wants to maintain his listed house with an energetic refurbishment, the situation is thus outlined.

*Behringstraße,
Hamburg, Germany*



Energetic refurbishment of a historic building – An unsure proposition

First of all, it must be stated that the owner is not obligated by the energy-saving ordinance to make an energetic refurbishment. There are, however, other reasons to reduce the energy consumption and CO₂ emissions of a listed building. There are idealistic grounds such as environmental and climate protection, and economical grounds such as rising energy and heating costs. In extreme cases, especially with regard to less-attractive locations, rising additional costs induced by heating could mean inefficiency of the building and, therefore, its deterioration.

The owner must ask himself which measures are realisable. Provided that he isn't an expert himself, he is instructed to seek the consultation of a respective professional. These are typically architects, construction engineers, energy consultants or landmark protection agencies, under the prerequisite that these experts have a respective interdisciplinary qualification in both landmark protection and building energy efficiency. Further sources of information, to which both the owner and the aforementioned experts can help themselves, are the norms, zoning laws, energy-saving laws, landmark protection laws and building regulations, as well as numerous publications on the topic and current research from colleges in this area of expertise.

On this basis, the owner, advised by the experts, has to make his decision for a proper batch of measures that must conform to the demands of the protection of the landmark. At the same time, it is determined that a decision with some degree of uncertainty has to be made because of the missing legal demands for historic buildings and specific, technical solutions that have mostly not been tested in a long time.

This uncertainty continues with the question of the costs of an energetic refurbishment. It pertains to the calculation of the costs as well as to the financing. Ordinarily, energetic refurbishment is not carried out on its own, but rather in the frame of a general reworking of the building. In the case of a necessary restoration of a roof, an energetic refurbishment can be undertaken at the same time, which naturally saves costs. Ideally, the costs of the energetic refurbishment will be covered by the saved energy costs. Based on experience though, energy costs are difficult to estimate because of the long-standing amortisation period of perhaps 20 years, and are thus afflicted with corresponding uncertainty. Furthermore, there are direct subsidies and tax breaks available for landmark restorations, but often no financial assistance from energy-saving programmes because their demands for historic buildings cannot be fulfilled.

The cost projection will moreover be decisively influenced by the qualification of the planners and the executive craftsmen. Specific expertise



*Just a brick illusion:
Insulation of the outer wall,
Hamburg, Germany*

in a combination of landmark protection and building energy efficiency is still difficult to come by. This drives up the costs due to missing alternatives on the one hand, and the danger of insufficient building construction on the other.

The aim of Co2olBricks: The reduction of this uncertainty

Through the work of the Co2olBricks project, existing uncertainty should be reduced, as the following examples show:

Through the collating and publicising of the carried-out restoration projects, the transparency of possible technical alternatives will be heightened. The pilot and accompanying research projects will illuminate the concrete implementation aspects and their implications. Planners, architects and energy consultants will benefit especially, as they will be able to better advise their customers and consequently curtail the inhibition level for the energetic refurbishment of historic buildings. More projects lead to more experience for all participants, and thus reduce the costs.

Co2olBricks partners



But political and administrative framework conditions can also reduce the aforementioned uncertainty, such as through the generation of appropriate technical norms; specific technical demands for the energetic refurbishment of historic buildings give planners, architects and energy consultants more security in their work, and are also welcome targets for possible financial assistance.

These financial stimuli for the energetic refurbishment of historic buildings in the Baltic Sea Region, which are broadly missing up to today, have one central function: they reduce financial uncertainties and thereby raise the probability that the owner will complete the refurbishment.

It thus appears clear that the various activities of the work packages necessitate and strengthen each other, and in the end bring the owners of listed buildings an enhanced position from which to make a decision.

2. Case study: Fæstningens Materialgård

Analysing and planning energetic refurbishment measures on a historic and listed site

What exactly are the main issues when we are talking about energy refurbishment of historic buildings? Even if you don't reach all aspects of a complex topic like this, it's always helpful to look at a specific case to make things a little bit more visible.

For the Co₂olBricks project partner from Denmark, the Danish Building Research Institute, SBI at Aalborg University, a report about a comprehensive refurbishment project in Copenhagen was produced in December 2011.

We talked about the main findings of the report with Torben V. Rasmussen, Senior Researcher at SBI. The complete report can be downloaded from the Co₂olBricks website (<http://www.coolbricks.eu/index.php?id=115>).

Co₂olBricks: What was the initial point for the energy refurbishment of the Materialgård building complex?

Torben V. Rasmussen: It was in 2007 that Realdania, a Danish real estate society, bought the building complex located at Frederiksholms Canal in the western part of downtown Copenhagen. The Realdania society holds members that own real estate in Denmark. Everyone who owns real estate in Denmark can be a member of the society. Realdania planned to build offices in the building complex. Although it is a common procedure to buy and sell in the real estate business, the Fæstningens Materialgård project was a special one, because Realdania purchases historic and modern buildings that serve "the common good". It's their goal to develop and preserve property, and furthermore to possess buildings with experimental aspects in, for example, location, design materials or methods of collaboration.

With this background, Realdania started the Materialgård project with the objective of making an energy analysis of the buildings and developing possible solutions to increase energy efficiency without destroying the buildings' historic value. Therefore all relevant stakeholders were to work together in an interactive process.

Co₂olBricks: Can you first tell us something about the historical background of Fæstningens Materialgård?

Torben V. Rasmussen: The history of the building complex goes back to the 17th or 18th century, when the old royal materials yard located in the fortress had to be replaced by a new one (Fæstningens Materialgård). The complex began in 1740 with a new, very distinguished brick residence for the supervisor. The architect of the building is not known for sure, but is assumed to be the national building master J.C. Krieger. The buildings form a single building complex, consisting of brick buildings with red tile roofs, yellow-lime washed facades, green-painted doors and gates and white-painted windows. Only the original warehouse building of the complex is built with a half-timbered construction.



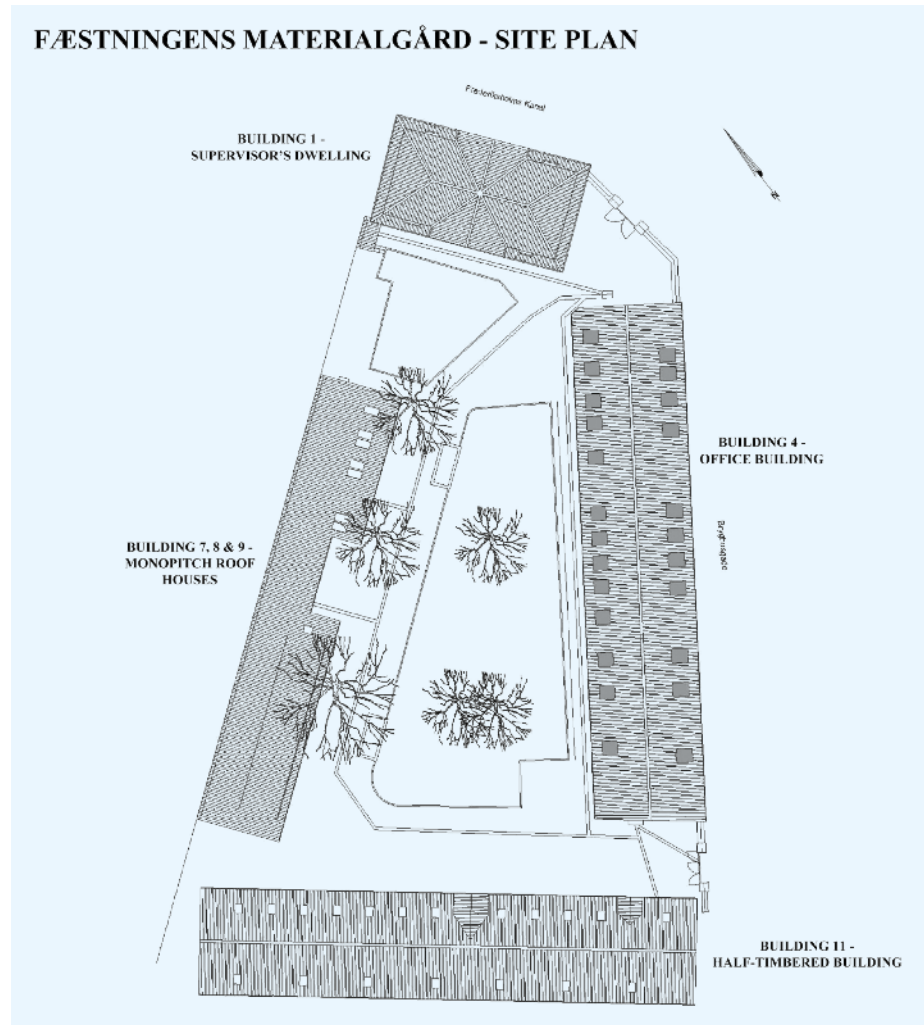
*Faestnings Materialgard –
Building complex,
Copenhagen, Denmark*

The use of the buildings has changed several times throughout their history. Recently the buildings have been used for different office-type functions. The current condition is affected by the many refurbishments of the building, which appear not to have resulted in serious settlement of the foundations. Nevertheless, cracks can be seen in some of the facades.

Co₂olBricks: What is the heritage preservation status and what does that mean to the owner of the building complex?

Torben V. Rasmussen: The buildings and the courtyard area have listed status. This listing is based on the Danish law protecting buildings and the conservation of buildings and the built environment according to the national legislation decree 1088. The aim of the law is to protect the country's older buildings of architectural, cultural, or environmental value, including buildings that highlight residential, working and manufacturing conditions as well as other important features of the development of the society. As the owner is required to maintain the building, Realdania took responsibility to restore the building complex. All building work that goes beyond normal maintenance requires permission from the Heritage Agency.

*Faestnings Materialgard –
Site plan, Copenhagen,
Denmark*



When carrying out building work on a listed building, the same techniques and materials that were used to construct the original building should be used. Building materials and techniques are characteristic of both the period and the region, which are an integral part of the culture of the building; they are therefore a part of its heritage value. This is especially applicable to proven materials and techniques that have been developed through experience over a long time. If experimental materials or techniques are to be used in a listed building, it should be ensured that they are implemented in such a way that they can be removed again.

Co₂olBricks: What are the fundamental heritage values of the Materialgård buildings?

Torben V. Rasmussen: In general, the group of buildings represents a landmark on the city's harbour front. It's a building complex with a long history and is an example of the expansion of Copenhagen in the late 17th and early 18th centuries, when the former city's defences were put to new uses.

In specific, each of the buildings has fundamental heritage values that had to be taken into account very carefully: e.g., the supervisory building with its

representative character and placement in the hierarchy of the complex, the hierarchy between the stories, the rooms and interiors containing a composition of historical styles and the joinery detailing. And the half-timbered house, which still preserved the storehouse character of the building, had clear constructions and rough, simple detailing.

Co₂olBricks: How did proposals for energy-saving initiatives come about?

Torben V. Rasmussen: The main idea was to develop solutions in an interdisciplinary work group consisting of the building owners, the authorities (Danish Agency for Culture [Heritage Agency], Danish Working Environment Authority), the architects and the engineers. Therefore, a detailed and interactive workflow was carried out in a series of consecutive steps.

The **construction brief** formed the basis for the energy project. The programme included the building history and a description of the existing conditions, together with an antiquarian/architectural values analysis of the building complex.

Initially, a comprehensive list of energy-saving initiatives was produced. This so-called **general list**, including 35 possible technical solutions, was created without regard to the architectural and heritage values of the buildings. The proposals did not take into account the location, the actual building geometry or the buildings' functions, which could have immediately meant that the proposals could not be implemented as described. The general list was created in order to look as widely as possible at all available initiatives, without taking into account the specific conditions of the buildings. Based on the general list, assessment schemes were created for all energy-saving proposals for future assessment.

Co₂olBricks: Can you tell us more about these assessment schemes?

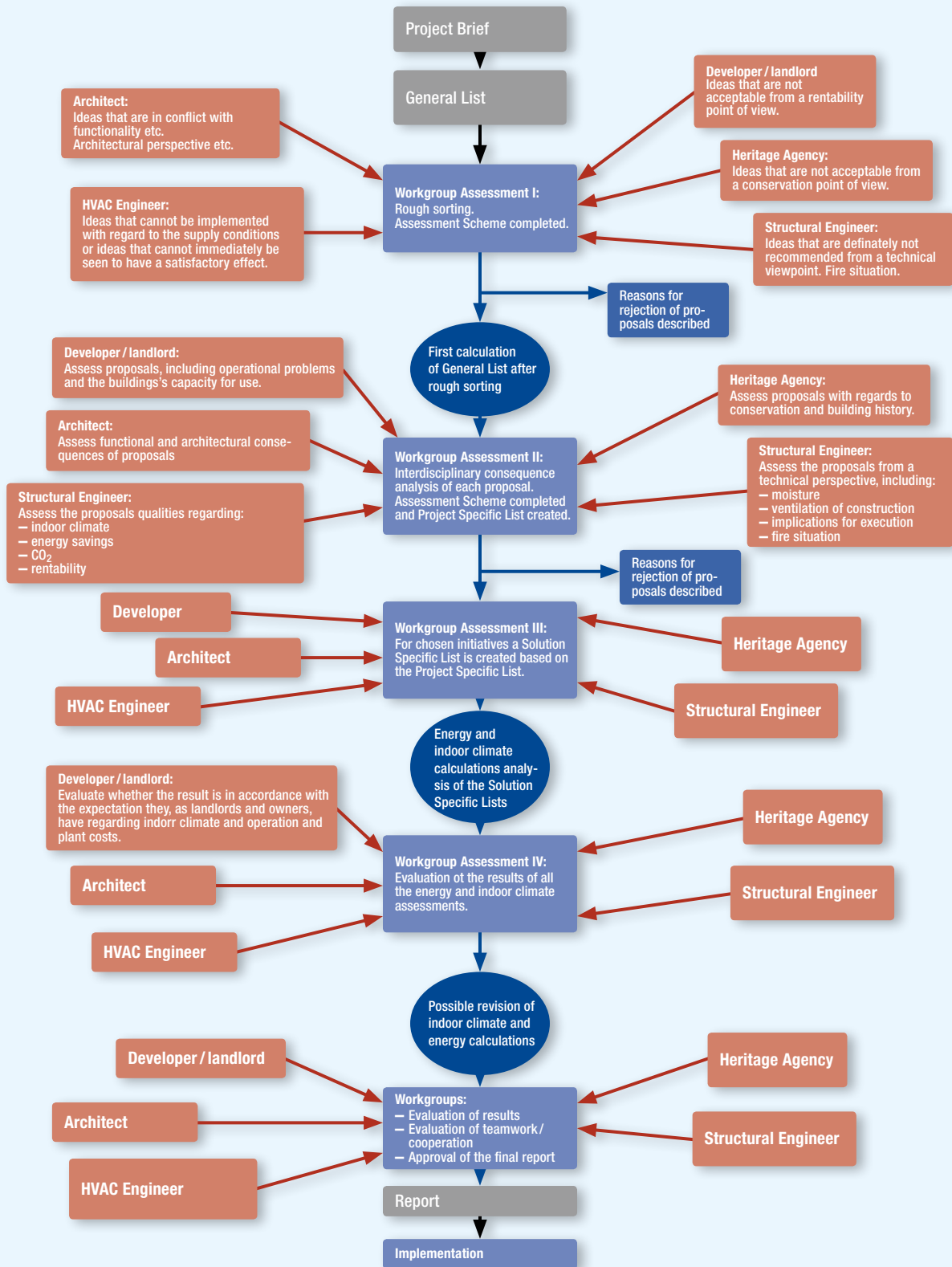
Torben V. Rasmussen: Each of the 35 proposed energy-saving initiatives was systematically assessed by participating experts in five different categories:

Heritage agency's assessment: Each of the proposed initiatives was evaluated individually for each building from a conservation/heritage point of view.

Wherever possible, a more general assessment/opinion of the proposed initiative was also given. These assessments/opinions were only for guidance, because the final, official approval can only be given once the entire project is submitted.

Structural engineer's assessment: All the proposed initiatives were evaluated specifically for each building from a structural design perspective. The impact of each of the initiatives on the existing construction was risk-assessed,

Fæstningens Materialgård – Work flow



Fæstningens Materialgård – Work flow

*Faestnings Material-gard –
Supervisors dwelling,
Copenhagen, Denmark*



especially with respect to moisture levels etc. Wherever possible, a more general assessment/opinion of the initiative was also given, with references to relevant literature.

Developer's assessment: The individual initiatives were evaluated specifically for each building from an owner's perspective. The impact of each initiative on, among other things, rental opportunities and operation/maintenance conditions were evaluated.

HVAC engineer's assessment: Each initiative was evaluated specifically for each building from an energy and internal climate point of view. The impact of the initiatives in terms of energy-saving effects and room temperature was evaluated especially critically. Wherever possible, a more general assessment/opinion of the initiative was also given, with references to relevant literature.

Further development: If a suggestion required further development, or if a material sample needed to be obtained before the initiative could be assessed, it was "recommended for further development". At this point, a comment was written about what documentation was required in order for the initiative to be assessed for a final approval/rejection.

Co₂olBricks: What was the main function of these assessment schemes?

Torben V. Rasmussen: They were used as a basis for **work group assessment 1**, which was a rough sorting of the general list that included all the proposed energy-saving initiatives. All the project group members conducted their overall assessments. Each proposal was thereby subjected to a first interdisciplinary evaluation. Based on this, an upgraded general list of proposals suitable for further work was produced.

For the **supervisor's dwelling**, for example, that means that, with great respect for the core heritage values of the building in mind, suggestions for

*Fæstnings Materialgård –
Interior, Copenhagen,
Denmark*



new energy-saving windows, external and internal solar shading, and internal and external post-insulation were rejected, along with a long list of other energy-saving initiatives. The majority of the energy-saving solutions for the electrical and service installations (replacing of glass in the secondary glazing, increasing the tightness of the building envelope and post-insulation of the sloping walls in the loft room) were, however, recommended for further development.

Co₂olBricks: ... and the next steps?

Torben V. Rasmussen: Before **work group assessment 2**, an estimated model was produced, based on the existing consumption readings for water, heating and electricity, for how the existing consumption, heat loss, hot water production, etc. was divided.

At the same time, all the buildings were entered into a simulation program for indoor climate/energy. The simulation model was supplied with the existing people loads and lighting systems. The model provided the opportunity to see the existing energy use divided between the building components, and also to get an idea of the existing thermal environment in different reference rooms spread over the different stories. Finally, element cards were produced for those energy-saving proposals from the general list that, based on the first evaluation, were recommended for further development. The element cards outlined each initiative's scope and effect on future energy consumption. The result of the second assessment was therefore a more detailed description of how the separate energy-saving proposals could specifically be carried out, as well as the impact of the proposals in terms of CO₂ savings, energy savings and indoor climate effects. The results were entered into the specific project list.

Looking at the **supervisor's dwelling** in the second work group assessment, solutions for ventilation, among other things, were presented. It was decided that any form of mechanical ventilation must be avoided, although it could clearly be seen that there was a need for temperature reduction in the rooms, even with a relatively low outside temperature. It was agreed that the HVAC (Heating, Ventilation and Air Conditioning) engineers would find examples of combined heating/cooling units for the group's next assessment in order to see if the unacceptable internal climate situation could be solved in that way.

Co₂olBricks: How were the initiatives evaluated in work group assessments 3 and 4?

Torben V. Rasmussen: Work group assessment 3 was conducted in order to make a solution-specific selection of energy-saving initiatives that supported each other and were reasonable in relation to the requirements for the interior layout. And **work group assessment 4** was undertaken to go through and possibly correct the adopted model, in case the initiatives did not altogether fulfil expectations and lead to the desired effects with regard to CO₂ savings, energy savings and indoor climate effects.

Through the third work group assessment, the combined heating/cooling unit solution for the **supervisor's dwelling** was found to be acceptable, although there was a requirement that the housing should be adapted so that it looked like a flat panel radiator. The work group agreed that 11 initiatives should be used to create the solution to be calculated: e.g., using energy-saving glass (3 mm glass set into the existing secondary glazing frames), building envelope air permeability and ventilating via opening windows. Through the fourth work group assessment, the results of the calculations were carefully reviewed. The work group assessed that the overall result can be expected to give a reduction in transmission loss of 27 % and an overall CO₂ reduction of 20 % for this building.

Co₂olBricks: What are the main conclusions of the Materialgård project?

Torben V. Rasmussen: First of all, it has been possible to show an expected relative CO₂ reduction of 18 % compared with the existing situation, whilst still showing the necessary respect for the core heritage values of the buildings.

Second, the restoration successfully secures an acceptable thermal indoor climate and allows the space to be used for an office. When listed buildings are used as office spaces, the **thermal indoor climate**, with regard to health and the working environment, is usually poor. This is usually due to the fact that earlier restorers were not aware of the need to establish ventilation and/



*Faestnings Materialgard –
Secondary glazing frames,
Copenhagen, Denmark*

or cooling when implementing classic energy-saving measures such as secondary glazing, post-insulation, etc. The thermal indoor climate often has an impact on which energy-saving initiatives can be implemented. The reason is that passive energy-saving initiatives (for example, post-insulation)

*Faestnings Materialgard –
Courtyard, Copenhagen,
Denmark*



frequently have an undesirable effect on the internal climate, as an increased insulation level result in an undesired higher room temperature. If the room temperature cannot be reduced to a reasonable level for a working environment through technical installations, such as ventilation or cooling, then the initiative should be rejected. This is common, as technical installations such as ventilation and cooling typically require a lot of space and are very visible, and therefore cannot be implemented in listed buildings due to a lack of supply routes. At the same time, the viability of passive initiatives such as post-insulation in terms of CO₂ should be carefully considered, as the net savings are reduced by the required (energy-intensive) cooling of the rooms in the spring and summer.

And last but not least, the **working method** used in the project has led to a comprehensive approach through which it has been possible to integrate design, supply routes and energy savings, without compromising the core heritage values. It is therefore possible to devise different solutions that together produce energy savings, combined with the creation of an indoor climate level, and that fulfil the requirements in the current Building

Regulations and requirements from the Danish Working Environment Authority for the design of permanent workplaces.

In general, this project can inspire building owners to face the restoration of listed buildings with a focus on energy-efficient solutions and the internal working environment climate conditions seen as a whole. This is relevant for more than 1,000 other listed buildings in Denmark that are used for office purposes.

Co₂olBricks: What about the realisation of the proposed measures and the current status of the project?

Torben V. Rasmussen: The restoration, including the implementation of all the initiatives that passed the final, official approval, has been carried out. The physical result, therefore, can now be seen by contacting Realdania. In a period of time to come, measurements documenting the energy use and the actual indoor environment of the restored and currently in-use complex will take place. The facilities in the restored complex, such as areas to be used as offices, are in the process of being occupied. Areas to be used as complementary facilities, such as rooms for meetings, a room for dining and a cantina, are also in the process of being occupied. The energy use, the expected savings and the indoor environment will be documented through measurements carried out in the restored complex. We're looking forward to seeing the results.

3. Status on energetic refurbishment of historic buildings in the Baltic Sea Region

The first step of the work within the Co₂olBricks project was to create a common basis for all participating partners. Therefore, baseline studies for each of the three work packages (“political development”, “technical solutions” and “education and economic promotion”) were compiled, in which the status quo was described on the one hand, and conclusions were drawn as a starting point for further activities on the other.

In the next three sections, the main results of the three baseline studies will be presented – the complete publications are available for download on the Co₂olBricks website (www.coolbricks.eu).

3.1. Political, administrative and financial issues

The baseline study of work package 3, “political development”, is an inventory of the administrative and legislative situation regarding the management of cultural heritage and energy efficiency questions in each country, as collected by the participating project partners. The aim of the study was to identify issues and topics that need to be brought forward in the partners’ stakeholder groups and in roundtable meetings in order to fulfil the main aim of advancing the political discussion on the national and transnational levels about the political and administrative anchoring of the essential combination of climate protection and cultural heritage aspects.

The baseline study consists of a summary of each partner’s national contribution, focused on energy and cultural heritage issues. The criteria of the baseline study were set by the project partners. The work package leader (the Swedish National Heritage Board) created a questionnaire from the different criteria and each country filled it out. The five common criteria for the baseline study upon which the partners agreed were the following:

Basic information: This is meant to give the background and some comparable statistics about the partner countries: e.g., population, building stock and administrative bodies concerned with cultural heritage, energy and climate protection.

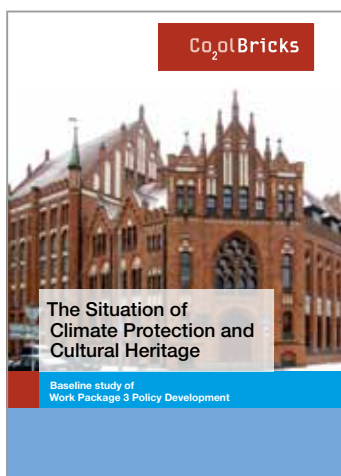
Cultural heritage: The partners were asked for a description of monument protection laws and how to define cultural value in a building before

refurbishment, and also about the definition of historic buildings and the eventual grading of, for example, listed buildings.

Energy supply and laws on energy efficiency: The partners were asked to give a description of their national adaptation to worldwide climate policy (the Kyoto Protocol) and the implementation of the directives of the European Parliament (2002 / 91 / EC and 2010 / 31 / EU on the energy performance of buildings and a report of the national Energy Efficiency Action Plan that is based on the requirements of Directive 2006 / 32 / EC on energy end-use efficiency and energy services). In addition, they were asked to give an illustration of the use and effects of energy audits in historic buildings.

Building regulations: The partners were asked about the implementation of the EU directives and the impact of building regulations on historic buildings. Baseline values for heat transmission were brought up as a question during the first partner meeting among the countries.

Financial mechanisms: The partners were asked for a description of the support or funding system for historic buildings and energy savings. The work package leader compiled the answers, and the results – to which every partner contributed – have been discussed among the partners. The baseline study points out some of the main problems and needs that are summarised in the following conclusions.



Cover of the baseline study of WP3

The **conclusions** of the baseline study of WP3 are:

The connections between energy and cultural heritage could and should be further clarified

None of the partner countries have specific national rules concerning energy supply and historic buildings, and none could specify the amount of energy historic buildings consume. The competent cultural heritage authorities do not have any influence on the legal process regarding energy efficiency in historic buildings. The cultural heritage regulations are used only to control the restoration and preservation of the cultural heritage objects; they do not focus on energy consumption.

There is a lack of knowledge and competence in dealing with energy efficiency in historic buildings

There is a need for specific know-how for architects, energy consultants, engineers and craftsmen. Also, among policy makers, the connection between energy efficiency and historic buildings has not been clarified. Very

few of the partner countries conduct energy audits in historic buildings. The system for energy audits has to be looked at more closely.

There is a need for a classification of methods when working with energy efficiency in historic buildings

None of the partner countries have, as yet, specific national rules concerning energy supply and historic buildings. There is a need for guidelines, standards or policies for the analysing, realising and monitoring of energy-efficient refurbishment of historic buildings.

The effect of building regulations on historic buildings needs to be discussed

Most of the partner countries' energy directives are implemented through building regulations, which impact energy efficiency in listed and historic buildings. This subject needs to be discussed in the project.

There is a lack of communication amongst the national authorities regarding subsidies

The financial mechanisms and legislation are not harmonised with the intentions of preservation. There is a need for specific public funding for energy efficiency in historic buildings.

The complete publication “The situation of climate protection and cultural heritage – Baseline study of work package 3: ‘policy development’” can be downloaded here: http://www.coolbricks.eu/fileadmin/Redaktion/Dokumente/Publications/01_Baselinestudy_WP3_Download.pdf

3.2. Technical solutions: The most common methods for improvement to energy efficiency

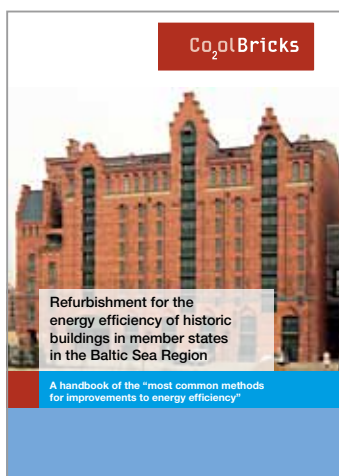
The handbook “Refurbishment for the energy-efficiency of historic buildings in member states in the Baltic Sea Region”, which is the initial result of work package 4, “technical solutions”, gives an insight into common methods of refurbishment for the energy efficiency of historic buildings in the participating countries, as collected by the project partners.

The set-up of the baseline study of WP4

The aim of the handbook is to shine a light on the current methods used for refurbishment for the energy efficiency of historic brick buildings in the

Baltic Sea Region. It serves as an exchange of various experiences and shows the different standards in the participating countries. By referring to this handbook, the project partners could start to develop common alternative procedures for refurbishment for energy efficiency that use improved techniques or new methods. This means the implementation of measures that do not alter the historic building itself: e.g. new heating systems, the improvement of windows, basements, ceilings and roofs, as well as the behaviour of the inhabitants.

The handbook consists of different examples of refurbishment for energy efficiency in the participating countries. The partners collected and selected the examples on their own, so it is not a self-contained compilation. The compilation of the examples was done by the work package leader, and the results were discussed within the partnership. Besides descriptions of examples from Denmark, Estonia, Germany, Latvia, Lithuania, Poland and Sweden, the handbook contains statements about the special ways in which refurbishment for energy efficiency is handled in Belarus, Estonia and Poland. Conclusions have been reached from this information.



Cover of the handbook of WP4

Summary of the conclusions

The conclusions concentrate on four points that have to be respected when engaging in refurbishment for energy efficiency in the future. Furthermore, the examples show that these points are not observed in the way this is handled in the present.

An extensive analysis has to be done before the refurbishment

The different materials of the individual components of the building must be sampled and examined. For example, the brick masonry's water content, water absorption, salt content and compressive strength have to be analysed. On this basis, the real values can be identified and used for simulations and calculations to develop the right measures to increase the energy efficiency of the building. Furthermore, the real energy-saving potential of the building after refurbishment becomes clear when looking at the situation at the beginning.

Examination of the cultural value of the historic building

It became clear in the compiled examples that the cultural value of the historic buildings had not been sufficiently examined. Before an historic building qualifies for energetic refurbishment, its cultural value has to be defined in order to implement the right measures to save energy. This will be the basis for the decision regarding which building components can be

refurbished based on the demands of energy efficiency and which determine the value of the historic building and have to be preserved in their original condition. After the refurbishment, the cultural value must be analysed again to determine the effects of the measures on the building's historic value.

Detection of real heat transmission values

After having a look at the examples and the calculations of the heat transmission values, it became clear that the refurbishments were implemented according to an acknowledged rule of technology: the measures implemented are all based on theoretical calculations of heat transfer, energy consumption and energy-saving potentials. No real values were gathered to form the foundation for the implementation of measures on historic buildings. The calculation methods are based on empirical studies and are made for the construction of new buildings; but historic buildings have completely different features. The individual features of a building are the crucial facts that have to be analysed before a refurbishment for energy efficiency takes place in order to provide the accurate energy-saving effects and therefore implement the right measures.

Upgrade of the evaluation of the refurbishment for energy efficiency

Before the implementation of energy efficiency measures, the evaluation of the measures already has to have been prepared. What the exact effect of the measure is has to be clear, as well as how much energy is saved in reality (compared to the calculated potential). Most of the refurbishments today are not evaluated in reality afterwards. Thus no empirical inquiries exist, but extensive evaluation will show which future measures are useful for saving energy and preserving the cultural value and which measures are not.

These conclusions will be used in the next steps of Co₂olBricks, when research will be implemented and pilot projects on brick buildings will be started. The aim is to find measures of refurbishment for energy efficiency that simultaneously decrease energy consumption and preserve the historic buildings.

The complete publication “Refurbishment for the energy efficiency of historic buildings in member states in the Baltic Sea Region – A handbook of the most common methods for improvements to energy efficiency – Baseline study of work package 4: ‘technical solutions’” can be downloaded here:

http://www.coolbricks.eu/fileadmin/Redaktion/Dokumente/Publications/02_Handbook_WP4_Download.pdf

3.3. Education and economic promotion

The aim of the baseline study of work package 5, “education and economic promotion”, was to provide a basis for further project development.

The main tasks in compiling this document were to collect and present descriptive information and comparable data to understand at a glimpse the specifics and necessities of each project country, to know the complexity of the labour market and education system in the Baltic Sea Region and to name the main problems to be met within the Co₂olBricks project in the education and economic promotion sector.

The data obtained from the project partners was supplemented by more general information from other available resources.

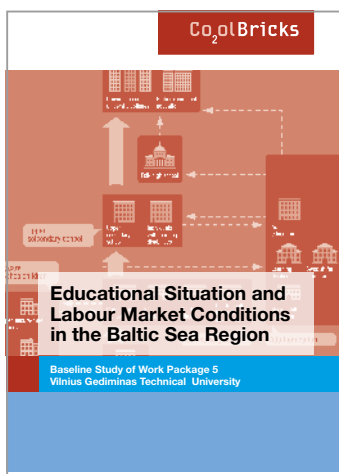
Main results

The educational systems of all participating countries are quite similar, containing most often three levels of education. There are also alternative education possibilities in all the countries where additional education is given (qualification courses for professionals, vocational training, etc.).

The Co₂olBricks project’s interests concentrate mostly on higher and further education for craftsmen, university education, education of working professionals and education for the general public (house owners, stakeholders, etc.).

Only few relevant education programmes and independent courses for energy efficiency include energy efficiency of historic buildings. There are either building engineering programmes that do not concern building preservation, or there are separate programmes for building conservationists with only little content on energy efficiency. The need for more education programmes or certain courses that combine both building conservation and energy efficiency is obvious.

Not only must the educational programmes be improved, but different target groups must also be addressed, which need deeper knowledge of historic brick buildings, historic values and techniques of suitable measures to improve living conditions in those buildings. The main target groups can be the general public, stakeholders, building companies, officials (such as building conservation officers, municipality representatives responsible for culture heritage and national refurbishment programmes), architects, building conservators, building supervising staff, energy auditors, teachers in universities, teachers in polytechnics, teachers in vocational training centres, students, working craftsmen, apprentices, etc.



Cover of the baseline study of WP5

Experts from the Co₂olBricks project's partner institutions have concluded that the general public is today missing knowledge as almost all target groups. The knowledge gaps pertain to the history of brick masonry, understanding the value and need of preserving original facades and understanding the dangers and damages that can be made by adding insulation to brick walls. The general public is usually very interested in possible subsidies for the refurbishment of historic buildings, which could be a way to attract them to seminars, workshops or other educational events.

Calculating energy efficiency in a comparable way is a common problem. This problem is met by energy auditors and is relevant when dealing with buildings of historic value. It can be made clearer by setting general rules, common measurements, etc. Such recommendations can be developed during the project period. Knowledge of building physics and structural damage should also be increased for this target group.

There is usually a misunderstanding between architects and conservators on which parts of the building should be preserved. In most of the Baltic Sea countries, conservators don't have a clear perspective of this, and architects usually collaborate with their clients, neglecting some historically valuable elements for the sake of making the building environment more modern. Although building conservators usually don't lack knowledge of historical masonry, they require knowledge of damage patterns of brick masonry construction, knowledge of moisture regimen and insulation types, knowledge of alternative solutions for improving indoor climate without changing the building's outer appearance (inside insulation, modern heating and ventilation systems, doors and windows, etc.).

Architects often specialise in either new construction or refurbishing. Those who work with old buildings usually have a very good understanding of cultural value, but their knowledge must be maintained and extended to new materials and repair methods. They do, however, usually lack knowledge of possible damages that the refurbishment of buildings can make to brick facades.

Conclusions

New lecture materials must be developed in order to inform the different target groups and raise their level of understanding. The big concern is the knowledge and education of the general public, house owners and stakeholders, because they usually initiate and influence most of the changes in valuable buildings. The missing knowledge can be divided into four main groups:

1. Cultural heritage and historic constructions
2. Energy-efficient refurbishment measures and technical services (heating, ventilation, indoor climate)
3. Quality management and work planning
4. Market opportunities

Topics	Special-ists	Craftsmen	General Public
1. Cultural Heritage	Large	Medium	Small
2. Energy Efficiency	Large	Large	Medium
3. Quality Management	Large	Medium	No Need
4. Market Opportunities	Large	Medium	Medium

Table 1: Need of additional knowledge for main target groups

The complete publication “Baseline study of work package 5: ‘education and economic promotion’” can be downloaded here: <http://www.coolbricks.eu/index.php?id=50>

4. Current and upcoming Co₂olBricks activities

4.1. Advancing the political discussion about the essential combination of climate protection and cultural heritage aspects

The main Co₂olBricks objective in the field of policy development is to advance the political discussion on the regional, national and transnational levels about the political and administrative anchoring of the essential combination of climate protection and cultural heritage aspects.

Based on the five conclusions of the baseline study (see Section 3.1) the participating partners will analyse and discuss the results with stakeholders. That includes a broad range of activities about different topics on all levels, such as the following:

- exchanges/discussions with other EU projects about specific European Standards (CEN) for the energetic refurbishment of historic buildings
- participating in the development of local funding programmes
- meetings, seminars and conferences to sensitise and inform the stakeholders

The results will be used on different levels. First of all, they will be used on the local, regional or national level to implement or adjust national heritage aspects into energy efficiency policy (or vice versa). Second, the results will be compiled by the work package leader, the Swedish National Heritage Board, and will lead to a common transnational declaration, which will be signed at the final conference of the Co₂olBricks project at the end of 2013. In the following sections, planned activities in the partner countries will be described.

Policy development in Germany

A number of activities with stakeholders will take place in Hamburg. Three events in the framework of “Architectural Summer 2012” have already taken place, where house owners, architects, planners and heritage preservationists discussed the energetic refurbishment of historic buildings with the example of a residential building from the 1920s. The Co₂olBricks partners from the heritage department and the Ministry for Urban Development will actively take part in the work group “Brick City Hamburg”. This will include the development of a local funding programme for brick buildings (“Backsteinfonds”) and an accompanying qualification programme called “Brick Consultant” (“Backsteinberater”) to build up special know-how for the

*Hamburg Summer of
Architecture 2012, Germany*



refurbishment of brick facades (this qualification will be mandatory to get money from the local funding programme for brick buildings).

On the national level, Hamburg is in contact with the CEN/TC356 mirror group, which is discussing a specific standard concerning the energetic refurbishment of historic buildings. Furthermore, the department for heritage preservation will disseminate the new public funding programme “Energy refurbishment of built heritage” and take part in the execution (e.g., as lecturers and multipliers) of the national qualification programme “Energy consultants for built heritage”.

Last but not least, a local guideline with specific information about energy refurbishment of listed buildings in Hamburg has been planned.

Policy development in Sweden

The four project partners from Sweden are active in this field on their individual levels and are coordinating their activities continuously.

The Stockholm City Museum will conduct expert seminars on “environmental assessment and classification methods for existing buildings” and “implementation and application of energy and preservation demands in the Swedish building regulations”. Both will include an open seminar for stakeholders. Further on, communication activities, including a traveling exhibition and articles in Swedish magazines such as *Arkitektur*, are planned. The Energy Agency for Southeast Sweden will organise a series of stakeholder meetings and seminars with, for example, representatives from counties in the region and regional county museums.

The Swedish National Heritage Board actively engages in a wide range of politics on a nationwide level. There are strategic individual meetings with Swedish national bodies, the housing board, the property board, the Environmental Protection Agency and the Energy Agency, among others.



*Värtan Gas works, Stockholm,
Sweden*

Expertise workshops will be organised within the CEN national working group for energy efficiency in historic buildings. Moreover, they will participate in a research project on “Potential and policies for energy efficiency in Swedish buildings built before 1945” and the Swedish national project “Spara Bevara”, which deals with energy efficiency with regard to cultural heritage.

The Environment Department of the city of Malmö will, among other things, organise some expert workshops with local stakeholders on the situation of historic architecture, energy efficiency and specific renovation projects, including public authorities as input to regional joint strategic activities.

Policy development in Denmark

The Co₂olBricks partner Danish Building Research Institute (SBI) conducts regular meetings with a stakeholder group twice a year. Members are from the Landowners’ Investment Association, the Danish Association of Construction Clients, the Danish Property Federation, the Danish University and Property Agency, and KAB – a customer-owned non-profit manager of housing associations.

Furthermore, the SBI develops knowledge through case studies and shares this in national and international papers. The report on the energy refurbishment of the building complex Fæstningens Materialgård has already been completed (see Chapter 2). An agreement on another report on the refurbishment of Countess Danner’s house is in process and a third case (a large multi-storey building, including dwellings) is planned.

*Co₂olBricks workshop in
Kohtla-Järve, Estonia*



Policy development in Estonia

The focus of the town government of Kohtla-Järve is on the local pilot project: a school building that should be refurbished in the future (see Section 4.2.3). In cooperation with the Information Center for Sustainable Renovation (SRIK) in Tallinn, research activities will be conducted and the results will be presented and discussed with stakeholders in seminars. The Centre for Development Programmes (EMI-ECO) in Tallinn will organise some seminars with stakeholders, for example, Kredex (a cultural heritage agency) or the Tallin city administration. Furthermore, discussions on funding schemes appropriate for Estonia and the production of recommendations and guidelines for builders are planned.

Policy development in Latvia

The policy development activities are tightly linked to technical aspects, which is no different from the other project partners. In Riga, the city government and the Riga Technical University are working together on the pilot project and accompanying research (see Section 4.2). They are building a basis for public relations work, a series of seminars and the production of case studies in order to disseminate the findings to a broad range of stakeholders.

Policy development in Poland

The European Foundation of Monument Protection in Gdansk is currently developing new cooperation models between administrators, architects and stakeholders. They will also organise a mixed group of auditors, architects, conservators, engineers, administrators and owners to analyse how funding, directives and standards influence the refurbishment of brick buildings. Furthermore, a specific workshop on policy development is planned.

Policy development in Belarus

The main focus in Belarus is on information about technical alternatives for the stakeholders. A number of events have therefore already taken place, including a conference on “Reconstruction and restoration of buildings and structures” and an international conference on “Energy-efficient construction: Modern energy-saving technologies”.

Policy development in Lithuania

In Vilnius, stakeholder workshops are planned for the Environment Ministry, the Culture Ministry and employees of the municipality of Vilnius to discuss the refurbishment of historic buildings. The main topics will be the key issues from the WP3 baseline study as well as the financial mechanisms.

4.2. Pilot projects and researches to proof technical alternatives

“Technical solutions”, work package 4 from Co₂olBricks, is the work package in which theory meets practice. Eleven partners from seven countries are involved in this package. They are gathering information about technical solutions for an energetic refurbishment of historic brick buildings. The techniques will not thereby damage the cultural value of the buildings; thus not every existing technical solution can be implemented in a worthwhile brick building. The task in work package 4, therefore, is to develop technical solutions and alternatives for general refurbishments or to determine existing solutions, analyse them and distribute them throughout the Baltic Sea Region and the European Union.

Three steps were set to achieve the goal. For the first step, a common handbook has been developed in which an overview and conclusions about the current situation of energy efficiency refurbishment in the project’s member states are shown (see Section 3.2). Second, the project partners started several researches on brick buildings all around the Baltic Sea Region that will be commonly evaluated. The third step will be the implementation of four pilot projects in which innovative techniques or methods will be applied. They are the tangible reality of Co₂olBricks, which will last through the project’s lifetime.



*Brick building in Alejas street,
Liepaja, Latvia*

4.2.1. Researches as current activities

Although Interreg projects are not intensive research projects, Co₂olBricks will implement several researches within work package 4 during its lifetime. Until now, eight researches have started on behalf of Co₂olBricks. Before the autumn of 2012, currently developing researches will be launched. The researches will gather information about thermal and moisture behaviour of historic brick buildings, as well as their energy consumption. Therefore, measurement tools have been installed on different buildings in different countries and will analyse the walls' behaviours and energy consumption. In this way, innovative techniques are examined by installing them on buildings and measuring their effects on existing structures. In general, the researches have been discussed during partner meetings, as well as via email and phone. Some of them were adjusted in the preparation phase due to common issues. During and after the implementation, the results will be evaluated transnationally with all involved project partners. Furthermore, the results will be transferred to work package 3, "policy development", and work package 5, "education and economic promotion". The scope of the launched researches will depend on the individual budgets of the implementing partners. At the minimum, the abstract of each research will be translated into English and published on the Co₂olBricks website. In the following sections, the researches in the participating countries implemented by the project partners will be briefly presented. Further and

ongoing information is available on the website or within the publications concerning the researches.

Research in Belarus

The innovation association Republican Centre for Technology Transfer (RCTT) in Minsk is getting funding from Co₂olBricks and is coordinating research. They are implementing an analytical review of Belarusian and foreign energy-efficient technologies and materials that can be used for the reconstruction and retrofitting of historic buildings.

An analysis of open-source information is being done. In addition, during the contest “Best Innovative Project (Technology) for Restoration of Historical Buildings”, organised by the RCTT in Belarus, several technologies were found and presented to other partners during project partner meetings. So far, the following information on technologies has been gathered: architectural products for restoration of historic buildings, vacuum insulation panels, foam glass insulation systems, super warm windows for energy-efficient buildings and flame- and bio-retardant agents for wood.

The aim of the activity is to present Belarusian and foreign technologies for energetic refurbishment in historic buildings. The research will be finished at the end of 2012. It is expected that technologies and materials from other project partners will also be assembled in a work package 4 handbook, which Co₂olBricks will then transfer to work package 5, “education and economic promotion”, for the education of craftsmen and planners.

Belarusian information material



Research in Denmark

The Danish Building Research Institute (SBI) at Aalborg University in Copenhagen is the research leader and implements the research in Denmark. SBI does not directly receive any funding from Co₂olBricks for researches. Nevertheless, they implement researches in the field of refurbishment of built heritage and make documentations about the results within Co₂olBricks. The Danish partner is studying three cases of recent energetic refurbishments of listed buildings in Denmark. The Danish Building Research Institute accompanies the refurbishment from the beginning until the end, and evaluates the implemented measures and methods.

In Denmark, the Heritage Agency is responsible for listed buildings while the local authorities are in charge of the buildings worthy of preservation. Most of the listed and preserved buildings are privately owned in Denmark. Therefore, the researches will focus on the cooperation between authorities and owners. They will examine the opportunities and measures required for carrying out an energetic refurbishment in the historic building stock.

Furthermore, the project partner will document on-site measures.

The aim of the research is to get examples of the best practices of energy efficiency refurbishment concepts of listed buildings. Measures and methods from the study strategies are being advised, so that the researches will gain knowledge about the success of special methods for energetic refurbishment and the best possible solutions. Because the process of implementing a common and coordinated refurbishment with the involvement of several parties with different interests is not frequently successful in the member states, the Co₂olBricks project will benefit a lot by the researches carried out in Denmark.

One report about the first case study, “Energy refurbishment of Fæstningens Materialgård”, was published in December 2011 (see the interview in Chapter 2) and is downloadable on the Co₂olBricks website. Two more case studies will be documented at the end of 2012 and the beginning of 2013. The necessary agreements with partners are in process.

Research in Tallinn/Kohtla-Järve, Estonia

The Information Centre for Sustainable Renovation, in cooperation with the city of Kohtla-Järve, is implementing research on a historic school building from 1938 in Kohtla-Järve, which will also be a pilot project within Co₂olBricks. The aim is an analysis of the hygrothermal performance of different interior insulation materials and a comparison of their features under the same conditions. The performance of the insulated wall will also be examined to find suitable solutions for an internal insulation that is safer and



*Humidifier in school building,
Kohkla-Järve, Estonia*

easier to implement than currently used materials in the Estonian climate. The indicators for a safer material can be the amount of condensation of water, mould growth, frost resistance, etc.

Therefore, four different insulation materials were installed on one wall in a room of the school building in the spring of 2012: calcium silicate panels, polyurethane foam board with capillary active pores, autoclaved aerated concrete and polyurethane insulation. The insulation systems were installed on a wall situated to the north. Each insulation material was installed on the wall in a one-meter-wide slice from the floor to the ceiling.

Measuring tools (for heat flux) were installed on the wall from the outside and on the surface of the internal insulation, as well as inside the materials. Furthermore, a humidifier and a heater were implemented in the room to realise different synthetic climate conditions next to the real-life climate by changing temperature and humidity via the Internet. During the measuring phase, the gathered data is also checkable via the Internet. This data will be used as a basis for the calibration of the computational model. The measuring phase lasts until the summer of 2013. The analysis of the hygrothermal performance of the building envelope will be done using a dynamic computer simulation (probably Delphin).

Finally, a report will be composed on the different materials to give an overview of the results. An assessment of the impact of different factors on hygrothermal performance and the energy performance of the different insulation solutions will be created.

Research in Tartu, Estonia

The Centre for Development Programmes (EMI-ECO) is implementing two researches financed by Co₂olBricks. One research project is located in Tartu, Estonia, and the other one is an overall research concerning examples of best practices.

In Tartu, EMI-ECO is analysing the primary energy consumption of 20 brick buildings spread over the whole city. Next to energy audits, special investigations concerning the energy performance of the buildings will be implemented. This study started in the autumn of 2011 and will be finished in 2012. After a comprehensive analysis of all 20 buildings, two buildings will be selected out of the pool to be examined in detail before the summer of 2013. This means that the indoor environment, especially the carbon dioxide emissions, the relative humidity and the temperature of the buildings, will be monitored and described. Furthermore, the building quality will be examined using infrared imaging, and the air-tightness and thermal bridges

*Brick building in Tartu,
Estonia*



of the building will be analysed. The aim is to find potential techniques and tools for the renovation of stone monument buildings.

Within the second research, existing practices will be examined and examples of best practices for energetic refurbishment will be carried out. The focus of the examination lies on the used technologies that reduce the energy consumption of buildings. The research started in the winter of 2011 and will also be finished in the summer of 2013.

Research in Hamburg, Germany

The Department for Heritage Preservation is implementing research on a five-storey residential building with a brick facade built in 1926/31 in Wilhelmsburg, Hamburg. The historic building is not listed by law, but is protected by conservation regulations of the city of Hamburg. The owner of the building is a housing company in Hamburg that will refurbish the building fundamentally and in an energy-efficient way. The building is in bad condition and the heating systems within the building are inconsistent in each flat, consisting of storage heating, gas heating and coal heat.

The research within Co₂olBricks focuses on the heating systems as a main energy-saving potential in historic buildings. Therefore, Co₂olBricks and the housing company will refurbish a minimum of four flats. In the first step, all flats will get new gas heating so that they all have the same basis and the energy savings will be comparable. In the second step, a conventional heating system with radiators will be installed in two flats, one flat with internal insulation, one without. A wall tempering system will be installed in the other two flats, one flat with internal insulation, one without. The wall tempering system acts as a radiation heating system and radiates heat waves into the room. There the surfaces and human bodies will absorb them. This

*Passierzettel, Hamburg,
Germany*



system has many advantages for the construction of brick masonry and people's health. On the one hand, it dries the construction, prevents condensate and partly insulates, and on the other, it is much more comfortable because radiation heating is natural for the human body. In all four flats, measuring tools will be installed to gather information about the energy transfer through the brick masonry in relation to the humidity of the construction. The energy consumption will also be monitored to compare the effectiveness of the different solutions. From these measurements, beginning in the autumn of 2012, results about the heating systems and their energy efficiencies will be found, which will be discussed with the Co₂olBricks partners and will influence the German pilot project.

Research in Germany, Kiel

A combined consulting and funding programme for the energetic refurbishment of historic and heritage-protected buildings in a residential area of the project garden city of Elmschenhagen-Nord in Kiel has been developed and implemented. The aim of the project is to motivate and support house owners in this quarter to implement high energy standards when refurbishing their houses. At the same time, the owners can receive advice on how to meet design specifications according to the binding land-use plan.

Elmschenhagen-Nord was constructed between 1939 and 1945. It includes 1,800 apartments: mainly attached houses made of red brick with homogeneously shaped front yards and spacious back gardens. As Kiel wants to conserve the quarter's characteristics in the long term, design guidelines have been fixed in the binding land-use plan.



Cavity wall insulation, Kiel, Germany



External wall insulation with brick tiles, Kiel, Germany

The architects Hahn, Saleh and Harten have developed a refurbishment concept for the prevailing house types of the quarter. This concept serves as a guideline for the consultation of the house owners. It shows the benefits of highly efficient insulation materials for cavity wall insulations, the choice of appropriate brick tiles in case of external wall insulation and new energy-efficient windows and doors that match the old ones. Thermal imaging provides quality control following the installation of wall insulations.

Measures that have already been implemented are:

- Cavity wall insulations with different materials on attached houses with subsequent thermal imaging
- Extensive refurbishment of an apartment building with cavity wall insulation, insulation of the roof and the basement ceiling, installation of new windows, installation of a thermal solar system and installation of a wood-pellet heating system
- Installation of an external wall insulation system with brick tiles, where cavity wall insulation was not possible; bricks and mortar were made to match the colour and texture of the existing buildings

During the next heating periods, the actual energy consumption of the implemented concepts will be compared to existing buildings with no refurbishment. Concerning cavity wall insulation, special attention must be paid to walls that are not in good condition and that are regularly exposed to wind-driven rain. Standards and guidelines for repairing joints, replacing bricks and correctly applying water repellents have to be developed in order to securely prevent rainwater from penetrating the outside wall and making the insulation damp. The consultations will be extended to owners of single-terraced houses and apartment buildings.

Research in Latvia

Riga Technical University is coordinating research in Latvia that consists of the development of different surveys and an examination. The aim is to gather information about available technologies for the decrease of heat consumption in buildings with brick facades and to determine the energy performance of architectural heritage buildings with brick facades. Therefore, a literature review has been done on the existing practice of architectural heritage buildings with brick facades and the implemented improvements to energy efficiency. Furthermore, a survey has been developed on research projects in the scope of framework programmes 5, 6 and 7 of the European Union. The research projects related to architectural heritage buildings with brick facades and/or that deal with energy efficiency

improvement have been examined. These surveys were implemented at the end of 2011 and were finished in the summer of 2012.

Riga Technical University is also implementing research on thermal flow and humidity on architectural heritage buildings with brick facades. Energy audits have thus been prepared for ten historic brick buildings in Riga. Thereafter, the installation of measuring tools and heat flux sensors will follow the monitoring of activities. The heat flux measurement will examine the humidity and temperature of the existing brick walls. Thermography equipment will be used to figure out heat bridges of the buildings while a construction diagnostic measurement kit checks the conditions of the walls. Conclusions will subsequently be made about the hygrothermal behaviour of the wall on the one hand, and the energy performance of the building on the other. On the basis of this gathered data and both surveys, recommendations for different refurbishment strategies will be prepared.

Liepāja, Alejas street, Latvia



Research in Poland

The European Foundation for Monuments Protection (EFOZ) coordinates and implements the research in Poland. The aim of the research is to figure out which internal insulation technology is effective for brick monuments and how much energy can be saved. Therefore, two case studies involving monuments will be examined. One brick building has already been refurbished and is in use as a museum, exhibition centre and conference hall (Museum of Solidarity). The other brick building is the manor house Studzienka, which will be refurbished in the near future. In both buildings, an internal insulation has been or will be implemented. EFOZ will compare the two case studies and give assessments on the effectiveness of the refurbishments.

*Manor house before
refurbishment, Studzienka,
Gdansk, Poland*



In the first step, existing documentations concerning the two buildings will be analysed. To find out the energy consumption of the buildings, energy audits will be executed before and after the renovation. This is not a common process in Poland because it is not required by law. As a result, it will become clear how much the energy consumption of the building decreases by implementing an internal insulation, in one case with the real, already implemented measure and in the other case with the theoretically expected consumption. Furthermore, energy parameters will be monitored during the implementation of the internal insulation. From this data and the comparison of the energy audits, a model for an energy audit of brick monuments will be prepared for the manor house and will contain suggestions for its refurbishment. The research will be presented in a report and the project documentation for the refurbishment of the manor house will be developed by the spring of 2013.

Research in Sweden

The Energy Agency for Southeast Sweden does not have a budget within Co₂olBricks to realise research. Nevertheless, they are implementing activities in work package 4 through support pilot projects in three regions in Sweden and are accompanying them through their realisation. They therefore exchange information, knowledge and experience about energetic refurbishment between Swedish regional pilot projects and Co₂olBricks and its 18 partners. The Energy Agency acts as a coordinator and is bringing in its own competence of energy efficiency measures in the pilot projects. Within the exchange between regional pilot projects and Co₂olBricks, the aim is to gain experience from earlier projects in which high energy efficiency measures and new technologies have been implemented. The Energy Agency

*Skeppsgossekasernen,
Karlskrona, Sweden*



will examine which measures are possible to implement when making old cultural buildings more energy-efficient and which measures damage the building or cultural value. Therefore, the Energy Agency is discussing these topics with stakeholders and is conducting workshops. One of the regional pilot projects is in discussion and the individual implemented measures will be analysed; two others will be prepared in the autumn of 2012.

4.2.2. Pilot projects – The built reality of Co₂olBricks

Next to research activities within the lifetime of Co₂olBricks, four pilot projects will be implemented in the Baltic Sea Region. New technologies, materials and innovative methods that have been gathered and compiled during the project's lifetime will be applied within the pilot projects. Through transnational cooperation, the pilot projects will be developed to last past Co₂olBricks' end and to present the results of the project. They are the built reality of Co₂olBricks and will be financed, at least in part, by investments from the individual project partners' budgets and the European Union. They will be used as on-site classrooms by the project partners, in close cooperation with work package 5, "education and economic promotion". Furthermore, the pilot projects will illustrate the problems of the administrative processes concerning the energetic refurbishment of historic buildings, corresponding to work package 3, "political development". And, of course, solutions will be applied within the pilot projects.

The pilot project in Kohtla-Järve, Estonia is a historical school building that is owned by the city and very much needs to be refurbished. The pilot project in Hamburg, Germany will examine a special heating system in residential brick buildings. In Riga, Latvia an information centre for innovative technologies

will be realised on a world heritage site. The pilot project in Sweden focuses on the usage of renewable energies and the lifecycle of energy-efficient measures by implementing a refurbishment of a former hospital area. The gathered data and determined conclusions from the pilot projects will be used for the project results and can influence future refurbishments of brick buildings outside of Co₂olBricks.

Pilot project in Estonia: School building in Kohtla-Järve

The Kohtla-Järve town government chose a historic school building as its pilot project. The building was constructed in 1938/39 by the architect Anton Lembit Soans, is a listed monument and is owned by the town government. The building consists of three stories and a gym hall. Parts of the gym were reconstructed in 1953 due to damages from the Second World War. The building is in a bad state and has to be fundamentally refurbished. The roof is not dense and the cellar is wet and sometimes flooded up to 50 cm. The building uses district heating with radiators that use gas by-products obtained from oil shale processing in the area of Kohtla-Järve. The current energy consumption is up to 356 MWh per year. The roofing has been changed to Eternit plates. The windows have partly been replaced; apart from the original wooden windows, new double-glazed plastic windows and new wooden box-type windows have been installed.

Today it is planned to reuse the building as an oil shale mining and processing museum. A sports club currently uses the gym to train local children; this usage will still remain in the future, beside the museum. To realise these usages, the building has to be refurbished fundamentally and in an energy-efficient way. Therefore, the town government of Kohtla-Järve has some investments in the projects budget for making some refurbishment in one part of the building in the interest of Co₂olBricks.

To prepare the refurbishment for the pilot project, the cultural value of the building has been documented and its energy consumption and performance has been analysed by Estonian experts. Next to that, two Co₂olBricks arrangements took place that provided the refurbishment development. First, the Information Centre for Sustainable Renovation, the Co₂olBricks partner from Tallinn, has started research on the building. Different internal insulation systems have been installed in a room of the building and are currently being analysed by measuring tools (see section 4.2.1). The results will be integrated into the development of the refurbishment concept. Second, the Co₂olBricks project started a workshop in the school building during its on-site partner meeting. In cooperation with different experts from the town government, the National Heritage Board and certain architects,

*School building in
Kohtla-Järve, Estonia*



the 18 partners from Co₂olBricks worked out different recommendations for an energy-efficient refurbishment of the building. The broad goal of the refurbishment is to save the building, save energy and thus the environment, save money and reduce carbon dioxide emissions.

Within the workshop, suggestions and recommendations were made for the construction of the wall. The wall, which is 60 – 90 cm thick, has to be kept dry and the water flow has to be controlled. Furthermore, the plaster has to be put in good condition to minimize frost damage and the yellow paint has to be replaced by mineral or silicate coating. A second group worked with the roof, cellar and windows. They recommended that fixing the roof to keep water out of the building is the most important aspect in the refurbishment. Moreover, the roof and the attic can be insulated without destroying the cultural value of the building. They suggested maintaining the existing drainage system and building further systems. The existing windows will be restored and renovated to save this essential part of the buildings' cultural value. To save energy, the windows can be improved by replacing the glass with insulation glazing. Replaced plastic windows will be rebuilt in wood and will have insulated glass. Group three suggested measures for the heating system. Dynamic heat regulations will be installed to control the heat consumption in individual parts of the building. Furthermore, a radiation heating system, i.e., a wall tempering system, has been recommended to heat at least the gym hall, if not the whole building. If funds are lacking, the existing radiators will be cleaned so that they can work more efficiently. The last group concentrated on the indoor environment and recommended installing a ventilation system with filters that would use outside air and heat exchangers. New shafts should hide behind existing forms. Moreover, the surfaces within the building will be warmed, which can be achieved by avoiding air movement.

In the framework of Co₂olBricks project some refurbishment work will be done in one part of the building: The gym hall. A technical concept will thus be developed and implemented during the project's lifetime, in which the workshop results will be regarded as far as the available funds allow.

Pilot project in Germany: Residential buildings in Hamburg

The Department for Heritage Preservation is supporting a residential refurbishment project on Holstenkamp street in Hamburg. The complex, built in 1922/23, consists of eight similar brick buildings surrounding a common green space. It has been listed since 2010 and therefore all modifications of the construction have to be coordinated with the Department for Heritage Preservation. Built as a retirement home by the city of Hamburg, it will now be developed into flats of 29 individual households by a private building community.



*Holstenkamp, Hamburg,
Germany*

The ensemble will be refurbished into flats with all the demands of modern living: insulation, comfort and a high standard of indoor air quality. Inspired by the Co₂olBricks project, the new owners want to implement an innovative wall tempering system in a minimum of two buildings in the complex. That means that loops of plastic covered copper pipe will be installed under plaster inside the external walls and will be heated by hot water. The wall tempering system acts as a radiation heating system and radiates heat waves into the room. There they will be absorbed by the surfaces and human bodies. This system has many advantages concerning the health of the people living in the flats, because air movement, and therefore also the transport of dust to

the mouth and nose, will be minimised. Comfort is also high because radiation heating feels natural for the human body. Next to these personal advantages, the system provides advantages for the construction of the historic brick masonry because the wall will be heated from the inside and will become the warmest point in the room. That means that it prevents condensate, that mould cannot grow and that the wall will be dried so that it insulates more than it would do in a wet condition. Because the wall tempering system runs at a lower temperature (35 °C) than normal heating systems (60 – 80 °C), much less energy is needed to heat it. Renewable energies, which can only provide low temperatures, can be used for the heating system. A reduction of carbon dioxide emissions down to zero would thus be possible.

To proof the effects and advantages, as well as to examine the handling of the wall tempering system in practice, the system will be implemented in a

*Wall tempering system,
Hamburg, Germany*



minimum of two buildings on Holstenkamp street. The results gathered from the research in four flats in Hamburg will influence the set-up of the wall tempering system. Measuring tools will be installed in the buildings to gather data about the effects and behaviour of the brick walls. In comparison to the innovative heating system, measuring tools will also be installed in a building with conventional radiation heating. So Co₂olBricks is comparing and studying the effects of radiation heating, which can be a solution to save energy and preserve the construction of historic buildings.



Model of the world heritage site, Riga, Latvia

Pilot project in Latvia: World heritage site in Riga

The city of Riga (Development Department) and the Board of Economics chose a building called Spīķeri in the UNESCO world heritage site “Historical Centre of Riga”. It is a warehouse complex located southeast of the inner city of Riga on the Daugava river coastline, and is an architectural heritage site of national significance. It was built between 1879 and 1882, when the suburbs surrounding the medieval town were laid out; it has a territory of 15,000 m². The pilot project in the framework of Co₂olBricks focuses on an information centre that was built in brickwork in 1930 in the middle of the warehouse district. It will be one element within the larger master project concerning the whole heritage site, where the main goal will be to refurbish the territory in different innovative and modern ways before 2014, when Riga becomes the cultural capital of Europe. The city of Riga and the EU have invested approximately €5 – 7 million in the whole heritage site.

The planned information centre will be financed from the Co₂olBricks budget and is currently in preparation. The aim is to implement an information centre that provides tourists with information about the world heritage site and shows the innovative technologies and materials for energetic refurbishment that Co₂olBricks developed and that will be implemented in the buildings of the warehouse complex. Therefore, the information centre itself will be refurbished into an energy-efficient building using new technologies. One main aspect will be the usage of renewable energies to lower carbon dioxide emissions. Solar panels and other alternative energy sources will be used to power the building. The information centre will thus be used as a showroom and an on-site exhibition in which different energy-

Pilot project, Riga, Latvia



saving technologies are presented. Co₂olBricks is thereby educating the public and experts.

As a first step, Riga Technical University analysed the condition and energy consumption of the building construction, brick walls, roof, windows, etc. Due to the former usage of the building, the walls are penetrated with nitrates and other substances that damage brick masonry. This will be fixed within the refurbishment, which starts in the summer of 2012. Before the analysis, the university developed a refurbishment concept of the building, into which the usage of the new technologies and renewable energies are integrated. It will set the framework for the presentation of materials and the concept of the centre. A draft of the concept is currently in reconciliation with the city administration and will be discussed with the Co₂olBricks partners.

As a second step, the university will monitor the whole project during the refurbishment and especially afterwards. They will gather data about the energy consumption and the effect of different materials on the construction of the wall. Measuring tools will therefore be installed on-site, in a way that makes them visible to visitors. The gathered data will be displayed in real time in the information centre in order to sensitise the public. A report will be created from the gathered data in which the success of the measure will be assessed.

Pilot project in Sweden: Former hospital area in Malmö

The city of Malmö is transforming a former hospital area (formerly called Östra Sjukhuset), in what is nowadays called Sege Park, into a residential area. In addition, some of the buildings will also house kindergartens and schools. Sege Park, characterised by green areas and parks, lies on the northern outskirts of Malmö, yet the travel time to the city centre is less than 15 minutes.

There are a number of different buildings in Sege Park, the earliest dating back to 1936, with others having been added in the 1950s and 1960s. The oldest parts will be refurbished due to the demands of the new usage, as well as for energy efficiency aspects. These listed buildings consist of eight two-



*Former hospital area,
Sege Park, Malmö, Sweden*

storey buildings in total, four on either side of a large, green park. It is this ensemble that is protected and worth preserving.

Within the refurbishment of the buildings, energy efficiency measures will be implemented. At the beginning, the Technical University of Lund analysed the energy-saving potential of a number of different measures: e.g., internal insulation, insulation of the roof and high windows, improvement of the ventilation and heating systems, as well as the possibility for solar energy production. The lifecycle of the individual measures in comparison to their costs and saving potentials was especially analysed. By taking a lifecycle approach (based on a lifetime of 100 years), it was calculated how high the initial investment costs can be while still being profitable in its lifetime. This analysis will be the basis for the development of the refurbishment concept. In a second step, the determined measures will be examined under the aspects of cultural heritage. So at the beginning of the planning phase, it has already become clear which measures can be implemented safely and which measures could have an impact on the cultural value of the former hospital buildings.

Experiences from a previous renovation project are taken into account as well. In the same area, a former gatehouse of the hospital area has been partly glazed in; i.e., a greenhouse has been built around the existing building. The gap of about 15 cm between the glass and the brick facade provides warm air in the winter and simultaneously improves the insulation values of the building. In the summer, the warm air can obviously be ventilated directly to keep indoor temperatures at convenient level. Since the implementation of this measure, the house has been rented out to two PhD students, who will analyse the energy demands of the house.

A main component of the refurbishment concept will be the usage of renewable energies in the whole complex. Therefore, solar panels especially will be installed on the roofs of the individual buildings and outbuildings in

*Former gatehouse, Sege Park,
Malmö, Sweden*



the hospital area (on the roofs facing away from the central, green park). The flats' heating systems and water heaters will be supplied with power by renewable energies. Storages will therefore be installed in the burrow system underground, which have been used as short connections between the hospital buildings to transport material and to provide space for infrastructure installations. This is a new concept of refurbishment, which will benefit Co₂olBricks. The city of Malmö's Department for Internal Services has investments from Co₂olBricks, which will finance parts of the energetic refurbishment and the renewable energy usage.

4.3. New lecture material, trainings and public information

Starting with the results of the baseline study, which defines a set of necessary material to be developed, the participating project partners are currently working on a set of activities that are in many cases closely connected with the other work packages, in that the same target groups are addressed (stakeholders) or the findings of the technical work package are directly integrated into lecture material.

In detail, this means the following:

Advanced knowledge for the general public and stakeholders

To create a general knowledge base about aspects of energy efficiency in the building sector, in combination with aspects of heritage protection and the promotion of sustainable and future-oriented decisions, several workshops for the general public, house owners and other stakeholders were or will be conducted. This includes, for example, three workshops for the "Summer of Architecture" in Hamburg, a short-term course for managers of householder

unions in Belarus and seminars and trainings for householders, landlords and the general public in Estonia. Manuals for best practices and guidance have been or will be established and shared by the Co₂olBricks website. In addition, a guideline for housing companies and property owners to assign the best suitable craftsmen to the energy-efficient refurbishment of historic buildings will be developed. The work package leader, Vilnius Gediminas Technical University (VGTU), is analysing the qualification requirements of workers and the certificates and requirements in existing building companies engaged in the refurbishment of historic buildings. The conclusions will be made regarding the qualification of the building company to be selected and the qualifications of the workers according to the specifics of the building to be refurbished. The recommendations will also be given in table form, where the works to be done, the specialities of the workers and the qualifications required will be listed.

Additional qualifications for energy experts and architects

To upgrade the knowledge of architects and energy experts on innovative techniques and products concerning the energy-efficient refurbishment of historical buildings, innovative training modules and curricula will be developed. VGTU has already drafted concepts for 15 different new training materials. These are currently being checked and adjusted by the participating project partners. The aim is to get a series of training materials that could be used as a common basis for all the countries in the Baltic Sea Region and that could be added to national, regional or local specifications. AZB Hamburg and VGTU are developing harmonised training programmes for architects, planners and energy auditors. Other partners from educational institutions (Riga Technical University, KIINKO Real Estate Education, the Centre for Development Programmes) will be adding developed lecture materials to their programmes too.

New training programmes, qualification tools and materials for specialised craftsmen

To upgrade the skills of craftsmen of different trades involved in the realisation of energy-efficient refurbishment measures, new and advanced training programmes will be developed. Without concrete competence from all crafts, the realisation of ambitious refurbishments is unfeasible. Under the lead of the Vocational Training Centre (AZB) in Hamburg, the guideline “Training and Education of Craftsmen within the Energy-Saving Refurbishment of Historical Buildings” will be developed. It will consider the possibilities of creating new training programme curricula, integrating new

*Training how to pass
in the mineral foam
insulation board onto the
interior window sill,
AZB, Hamburg, Germany*



training modules into existing curricula and developing new material for specialised craftsmen.

In Estonia, special trainings for craftsmen, constructors and facility administrators and maintainers are planned.

Cooperation of curricula for craftsmen in the Baltic Sea Region

The curricula of craftsmen have to be harmonised to support the mobility of labour, to spread the mediated qualification and knowledge and to give innovative small- and medium-sized enterprises (SMEs) the possibility to implement their techniques and products.

Therefore, AZB Hamburg is developing a certification scheme for curricula and training modules for specialised craftsmen to use it in the own organisation. This scheme will be presented and discussed within the project and could be used in a first step as a template by the project partners for their own purposes.

Strengthened market opportunities of innovative SMEs in the Baltic Sea Region

In order to strengthen the possibilities for innovative SMEs to implement their techniques and products in the Baltic Sea Region, the project partners will promote the advanced techniques and products of SMEs by integrating them into training programmes and workshops.

The frequently conducted international seminars and transnational meetings of Co₂olBricks have the same objectives: to discuss the findings of the project with the mainly local experts and stakeholders and to present alternative technical solutions and products for the energy-efficient refurbishment of historic buildings.

Public relations activities such as articles in local newspapers (for the general public), expert magazines (for architects, engineers, etc.), special interest publications (for education) and scientific journals (to publicise the results of activities and researches) will accompany all these measures. Furthermore, the Co₂olBricks project was presented at the public fair “Self-Education Career 2012” in Vilnius, Lithuania, where contacts with other teaching institutions from the Baltic Sea Region were established.

Photographs

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European Foundation of Monuments Protection*

Page 45: *Marlene Bergström, Swedish Property Board*

Page 50: *Riga City Council*

Page 51: *Gatis Zogla, Riga Technical University*

Page 55: *Ausbildungszentrum Bau Hamburg*

Annexes

I. Networking – Co₂olBricks partners and related projects

1. Co₂olBricks project partners:

- Free and Hanseatic City of Hamburg, Ministry of Culture and Media, Department for Heritage Preservation
- Free and Hanseatic City of Hamburg, Ministry of Urban Development and Environment, Cooperation Centre for Climate Issues
- Vocational Training Centre Hamburg (AZB Hamburg)
- City of Kiel, Department of Environment
- The Stockholm Cultural Administration/Stockholm City Museum
- Energy Agency for southeast Sweden, Växjö
- Swedish National Heritage Board, Department of Conservation, Visby
- City of Malmö, Environment Department
- Danish Building Research Institute (SBI) at Aalborg University
- Information Centre for Sustainable Renovation NGO (SRIK), Tallinn
- Kohtla-Järve Town Government
- The Centre for Development Programs, EMI-ECO, Tallinn
- Riga City Council, City Development Department
- Riga Technical University
- European Foundation for Monuments Protection, Gdansk
- RCTT – Republican Centre for Technology Transfer, Minsk
- KIINKO – Real Estate Education, Helsinki
- Vilnius Gediminas Technical University

Detailed contact data and links to the project partners' websites are available on <http://www.coolbricks.eu/index.php?id=54>

2. Related Projects

3ENCULT (Efficient Energy for EU Cultural Heritage) <http://www.3encult.eu/en/project/welcome/default.html>

ALPhouse (Alpine Building Culture and Ecology) <http://www.alphouse.de/>

Baltic Biogas Bus Project <http://www.balticbiogasbus.eu/web/>

Bioenergy Promotion (The Bioenergy Promotion project will promote the development of a sustainable production of and commercialisation of biomass in the Baltic Sea Region) – <http://www.bioenergypromotion.net/>

BSRQuick (Qualification, Innovation and Cooperation for Small and Medium Enterprises in the Baltic Sea Region) <http://www.bsr-quick.eu/>

Climate for Culture <http://www.climateforculture.eu/>

- E2 Rebuild** (Industrialised energy efficient retrofitting of residential buildings in cold climates) <http://www.e2rebuild.eu/en/Sidor/default.aspx>
- EVoCH** (Economic Value of European Cultural Heritage) <http://www.evoch.eu/index.html>
- HEALTH** (Healthy and energy efficient living in traditional rural houses) <http://helthproject.eu/>
- Longlife** (Sustainable, energy efficient and resource saving residential buildings in consideration of unified procedures and new and adapted technologies) http://www.longlife-world.eu/home_en.html
- New4old** (New energy for old buildings) <http://www.new4old.eu/>
- PEA** (Public Energy Alternatives) <http://www.peaproject.eu/>
- REMOWE** (Regional Mobilizing of Sustainable Waste-to-Energy Production) <http://www.remowe.eu/>
- SECHURBA** (Sustainable Energy Communities in historic urban areas) <http://www.sechurba.eu>
- Spara och Bevara** <http://www.sparaochbevara.se/>
- SPIN** (Sustainable Production through Innovation in SMEs) <http://www.spin-project.eu/>
- SuHiTo** (Sustainable Historic Towns) <http://balticheritage.raa.se/groups/towns.html>
- UrbEnergy** (Energy Efficient and Integrated Urban Development Action) <http://www.urbenergy.eu/>
- Cluster Energy** – cluster initiative of “Energy Efficiency and Renewable Energy Sources” in the BSR http://www.longlife-world.eu/cluster_en.html

II. Know How – Sources of valuable information

Transnational

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“Value creation and New Business models by Energy Efficiency Measures in Historical Buildings”, EVOCH – Economic value of cultural heritage (2011): http://www.evoch.eu/mediapool/101/1011559/data/Conclusions_EVoch_expert_seminar_Koblenz130511.pdf

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Austria

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Croatia

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England

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Norway

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**BUILDING 7, 8 & 9 -
MONOPITCH ROOF
HOUSES**

**BUILDING 4 -
OFFICE BUILDING**

Bryhnusgade

Imprint

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