Co$_2$olBricks

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"

Editor/ Lead Partner:

Hamburg | Denkmalschutzamt

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Summary

Co2olBricks – Climate Change, Cultural Heritage and Energy-Efficient Monuments is a project in the framework of the Baltic Sea Region Programme 2007 – 2013. The project consists of 18 partners from nine countries. One of the project's main objectives is to develop new methods and measures to implement refurbishment for the energy efficiency of historic brick buildings without destroying their cultural value. By the end of 2013 *Co2olBrick*s will have compiled the results in the work packages *Policy Development* (WP3), *Technical Innovations* (WP4) and *Education and Economic Promotion* (WP5). This means the project will declare a transnational common position concerning the energy efficiency of historic buildings, it will find new technical solutions for their refurbishment and it will upgrade the knowledge of craftsmen, architects and engineers. Lead Partner is the Department for Heritage Preservation of the Ministry of Culture in Hamburg. Further information is accessible on the project website: *http://www.co2olbricks.eu/*

This paper presents the handbook *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"* which is the initial result of Work Package 4 *Technical Innovations*. The handbook 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 aim of the handbook is to shine a light on the current methods used for refurbishment for energy efficiency in historic brick buildings in the Baltic Sea Region. It serves as an exchange for various experiences and shows the different standards in the participating countries. By referring to this handbook, the project partners can start to develop common alternative procedures for refurbishment for energy efficiency which use improved techniques or new methods. That means the implementation of measures that do not alter the historic building itself are also possible, e.g. a new heating system, the improvement of windows, basement, ceilings and the roof as well as the behaviour of the inhabitants.

The handbook consists of different examples of refurbishment for energy efficiency in the participating countries. Each partner collected and selected the examples on their own, so it is not a self-contained compilation. Thus the information for the examples is

different from example to example. The compilation of the examples was done by the Work Package Leader and the results were discussed within the partnership. Besides the description of the 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.

Summary of the conclusions

The conclusions concentrate on four points which have to be respected when engaging in refurbishment for energy efficiency in the future. Furthermore, the examples show that these points have not been observed in the way this has been 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, 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, after looking at the situation at the start, the real energy saving potential of the building after the refurbishment becomes clear.

Examination of the cultural value of the historic building

It became clear in the examples compiled that the cultural value of the historic buildings had not been sufficiently examined. Before an historic building qualifies for energy-efficient 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 due to 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 the 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 had been gathered to form the foundation for implementation of measures on historic buildings. The calculation methods are based on empirical studies and made for the construction of new buildings; but historic buildings have completely different features. The individual features of a building are the crucial facts which have to be analysed before a refurbishment for energy efficiency 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

During the implementation of energy efficiency measures, the evaluation of the measures already has to be prepared. What the exact effect of the measure is has to be clear, and how much energy has been saved in reality (compared to the calculated potential). Most of the refurbishments today are not evaluated in reality afterwards. Due to that fact, no empirical inquiries exist, however, extensive evaluation will show, in the future, which measures are useful while 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 is implemented and pilot projects on brick buildings are started. The aim is to find measures of refurbishment for energy efficiency which, in parallel, decrease energy consumption and preserve the historic buildings.

› … the project will declare a transnational common position concerning the energy efficiency of historic buildings, it will find new technical solutions for refurbishment and it will upgrade the knowledge of craftsmen, architects and engineers. ‹

1. Introduction

This brochure is the initial result of Work Package 4 of the project *Co₂olBricks – Climate Change, Cultural Heritage and Energy-Efficient Monuments* and shows examples of refurbished historic buildings in the participating countries. The project is partly financed by the European Union Regional Development Fund and the European Union Neighbourhood Partnership Instrument.

a. Presentation of Co_2olBricks

In the framework of the Baltic Sea Region Programme 2007 – 2013 the project *Co_2olBricks – Climate Change, Cultural Heritage and Energy-Efficient Monuments* was approved in September 2010 and started its work at the beginning of 2011.

The European Union's Baltic Sea Region Programme2007 – 2013 promotes regional development through transnational cooperation. The strategic objective is to make the Baltic Sea region an attractive place to invest, work and live in. The Programme co-finances Co_2olBricks, which is a project in the Priority Area 1: Fostering Innovation. Innovation means successful production, assimilation and exploitation of novelty in the economic and social spheres. The priority supports innovation sources and facilitation of transnational transfer of technology and knowledge, in particular targeted at small and medium-sized enterprises (SMEs). Another objective is to strengthen the capacity of people for absorbing new knowledge.

The project consists of 18 partners from nine countries and has an overall budget of € 4.3 million. One of the main objectives is to develop new methods and measures to implement refurbishment for the energy efficiency of historic brick buildings without destroying their cultural value. By the end of 2013, Co_2olBricks will have compiled the results in the work packages *Policy Development* (WP3), *Technical Innovations* (WP4) and *Education and Economic Promotion* (WP5). This means the project will declare a transnational common position concerning the energy efficiency of historic buildings, it will find new technical solutions for refurbishment and it will upgrade the knowledge of craftsmen, architects and engineers.

Lead Partner is the Department for Heritage Preservation of the Ministry of Culture in the Free and Hanseatic City of Hamburg. Further information is accessible on the project website:
http://www.co2olbricks.eu/

b. Partner structure in Work Package 4

Altogether 18 potential partners from the Baltic Sea Region programme area cooperate in Co_2olBricks. Over 30 associated partners from all around the Baltic Sea support the activities and results of the project. Eleven partners from seven countries are involved in Working Group 4 *Technical Innovations* whose aim is to find new technical solutions concerning the energy-saving potentials of historic buildings and to implement, monitor and evaluate pilot projects in historic buildings with optimised energy consumption. These eleven partners developed the current edition of this publication. They are:

Country	City	Organisation
BELARUS	Minsk	Republican Centre for Technology Transfer
DENMARK	Copenhagen	Aalborg University, Danish Building Research Institute
ESTONIA	Kothla-Järve	Town Government
ESTONIA	Tallinn	Centre for Development Programs (EMI-ECO)
ESTONIA	Tallinn	Information Centre for Sustainable Renovation
GERMANY	Hamburg	Department for Heritage Preservation
GERMANY	Kiel	Environment Department
LATVIA	Riga	City Development Department
LATVIA	Riga	Riga Technical University
POLAND	Gdansk	European Foundation of Monuments Protection
SWEDEN	Växjö	Energy Agency Southeast Sweden
SWEDEN	Malmö	Environment Department

The other partners of Co_2olBricks can be found below. Almost every partner works in at least two work packages:

Country	City	Organisation
FINLAND	Helsinki	KIINKO Real Estate Education
GERMANY	Hamburg	Development and Environment Department
GERMANY	Hamburg	Vocational Training Centre
LITHUANIA	Vilnius	Vilnius Gediminas Technical University
SWEDEN	Visby	Swedish National Heritage Board
SWEDEN	Stockholm	Stockholm City Museum

c. Contents and aims of the compilation

This handbook is the initial result of activities in Working Group 4 of the project Co$_2$olBricks. In this review all participating partners, under the coordination of the Work Package Leader, collected examples of historic buildings refurbished for energy efficiency that have been carried out in the different countries. The following examples do not show the highest standards or the newest techniques for a refurbishment for energy efficiency, only for refurbishment in an ordinary way. It is not the high-class refurbishments in every participating country which are interesting for this brochure. It is the common methods of refurbishment for energy efficiency of historic buildings in the participating countries which are outlined and the state of refurbishment today which needs to be brought up to a more advanced state. But, simultaneously, the heritage values have to be protected by implementing measures for energy efficiency.

For a clear and easy understanding among the project partners and project external stakeholders, a definition is given here of the buildings Co$_2$olBricks is dealing with. Co$_2$olBricks is focusing on: *architecturally, culturally or historically valuable buildings*, which are referred to as "historic buildings" in the handbook and the following project work. This definition is independent of the national laws and regulations for heritage preservation which differ greatly between the member states.

A part of these buildings are what we in Co$_2$olBricks call "listed" buildings. This encompasses all buildings that are architecturally, culturally or historically valuable buildings and have a legal status that exempts them from energy efficiency obligations and which, for example, cannot be demolished or altered without the permission of the authority responsible for the heritage preservation of the respective country, state, county or municipality.

The project focuses on the refurbishment for energy efficiency of historic buildings. An *energy qualification* is defined as a refurbishment which reduces the energy consumption of a building. That means the installation of insulation could be an energy qualification as well as the renewal of the heating system or the improvement of existing windows. One may ask why Co$_2$olBricks is dealing with this topic, especially since listed buildings are exempt from the obligation of energy efficiency improvements in most countries. The answer is: It will become more and more necessary for historic buildings to be energy-efficient.

On the one hand the worldwide demand for reducing carbon dioxide will rise; the environment and the climate have to be protected. Therefore the measures to mitigate the effects of climate change are high-priority issues in industrial countries and thus also in the Baltic Sea Region. The countries have upgraded their demand for energy savings in the existing stock of buildings continuously for the past 30 years, not only since the development of the EU Directive of Energy Performance of Buildings (EPBD). This means even the historic buildings and monuments are in competition with the rest of the building stock.

On the other hand, the prices for energy are still rising and owners and tenants will not pay unlimited energy costs. Therefore, even historic buildings might have to reduce their energy consumption to remain attractive and in use. Only a building which is being used will be maintained and thereby preserved in the future. Historic buildings have to be economically viable to be competitive with new buildings. Presently the listed buildings may be exempt from the legal energy qualification demands but in the future they might not be. The political developments in some countries hint at a movement in this direction. Furthermore, that the energy efficiency standards for new buildings will be assigned to historic buildings as well must be reckoned with.

The handbook focuses more on the measures for refurbishment which is energy-efficient rather than on a detailed description of the cultural heritage value of the building. Even though $Co_2olBricks$ concentrates on these aspects, the cultural value has to be defined more precisely. It has to be analysed in detail before the implementation of suitable measures for refurbishment are prepared.The following examples will only provide a glimpse of the current ways in which refurbishment for energy efficiency in the historic building stock in the Baltic Sea Region is carried out. They serve as an exchange for acquired experiences and show the different standards in the participating countries. Therefore the examples constitute the starting point of the work in Working Group 4. By referring to this handbook, the project partners can together start to develop alternative ways of refurbishment for energy efficiency which use improved techniques or new methods. This will then be commonly implemented in pilot projects in selected participating countries.

› The big advantage derived from this measure is that the original façade and thereby the appearance of the building will be preserved. ‹

2. Examples

Each project partner selected the examples of energy efficiency improvements which are presented below. The examples of refurbishment for the energy efficiency of historic buildings show the most common methods of refurbishment which have been carried out in the different countries. This is not meant to be a display of high-class refurbishment pilots. Instead, it shows the wide variety of different approaches towards energy-efficiency improvements used in the participating countries. Furthermore, the selection of the examples depended on the individual role of the participating partner and the task of the institution.

This means that not every respective building example is comparable with another, due to the fact that, on the one hand, the countries deal with the refurbishment aspect differently and, on the other hand, not all of the different institutions have access to comparable data. Therefore some partners could not follow the requested plan because no refurbishment for the energy efficiency of historic buildings takes place in their country, for example in Belarus and Estonia. However, all partners did their best and cooperated with associated partners or contacted stakeholders.

The selected examples are sorted into categories of which measures were implemented: with internal insulation; with external insulation; or, no measures due to the demands of heritage preservation. Thereby it shows the most common ways refurbishment for the energy efficiency of historic buildings in the participating countries takes place. But this is only a selection of examples and not a final compilation which presents all the approaches in each country.

a. Examples with internal insulation

One common way of undertaking refurbishment for energy efficiency is the implementation of measures on the inside of a building, as the selected examples from the participating countries show. This method seems to increase the energy efficiency of a historic building. The big advantage derived from this measure is that the original façade and thereby the a ppearance of the building will be preserved. The following examples illustrate how differently each participating country deals with internal insulation and how it has been done in different types of buildings with different construction preconditions. Furthermore, it shows which additional measures have been implemented.

DENMARK
Copenhagen, Frederiksberg

Year of construction: 1889

Architect: Unknown

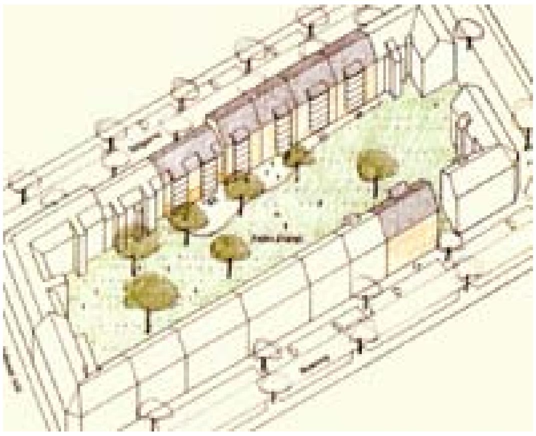
Heritage status: The street façade is protected by heritage preservation.

Building type: Apartment building (10 flats)

Floor space: 690 m², 709.5 m² after refurbishment

Implementation of refurbishment for energy efficiency: 2000 / 2001

DK



Saving of energy:

The overall saving of energy is unknown for this building. Calculated values estimate an energy-saving potential of 30 kWh / m² / a but without the savings related to the new heating system and the insulation of pipes. This means the saving potential comes from the internal insulation measures, the insulation of the roof and the cellar as well as from the new windows. Furthermore, renewable energy is integrated into the concept: Solar gain from windows heating the open space in the new kitchens.

Measures implemented:

The aim was to implement a high technical standard within the historic building to achieve lower energy consumption for room heating, hot water and ventilation. The apartments were modernised, with new bathrooms, kitchens, radiators with a thermostat for heating, windows and the outer doors.

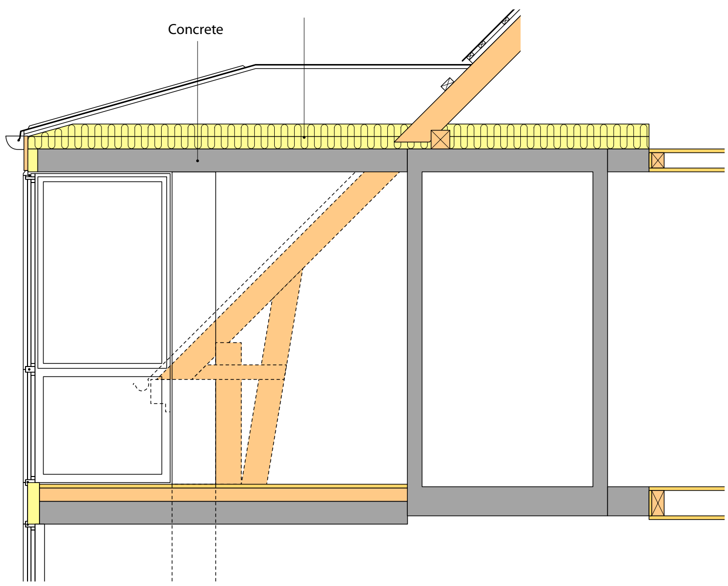
The façade to the street had to be preserved due to heritage preservation issues. The single-leaf brick masonry of the street façade had been well preserved in the past. Therefore just single damaged bricks were replaced in the façade. The façade facing the backyard was retrofitted: The back stairs were removed together with the original bathrooms and replaced with prefabricated bathroom cabinets and an extended horizontal partition of concrete to be used as the kitchen.

A window frame wall covering the new kitchen space was chosen as the new façade facing the backyard.

Furthermore, the 45 degree angled double-pitched roof was also replaced. Insulation (150 to 230 mm mineral wool) was installed between the rafters and on the floorboards in the ventilated attic room. The cellar ceiling was supported by good-quality timber beams with the dimensions 200 mm by 200 mm. The ceiling was lowered and insulated with 100 mm mineral wool, and along with it a new cladding (13 mm gypsum boards) was installed.

The existing single-leaf windows were replaced by double-glazed windows in the street façade–as a sealed unit mounted in a Dannebrog formation frame due to heritage preservation issues. The windows in the façade facing the backyard were also replaced by the same windows due to heritage preservation issues.
A district heating station had been set up and so a new central heating system was installed and the pipes in the basement were insulated. The prior heating system consisted of electrical heaters, an all-night burner and paraffin heating systems in each flat. The existing passive ventilation system extracted the air through a ventilation shaft. A central mechanical extraction set connected to the cooker hood was installed.

Special information:
The refurbishment was implemented after a previous engineering evaluation of the building. Afterwards architects and engineers developed the project and supervised the refurbishment. The project was carried out completely by a building contractor. The renovation costs are unknown for this project.



Vertical section of the roof above the apartment in the former attic room.

DENMARK
Copenhagen, Hellerup

Year of construction: 1904

Architect: Unknown

Heritage status: The wall facing the street is protected by heritage preservation

Building type: Apartment building (20 flats and 8 shops)

Floor space: 2628 m²

Implementation of refurbishment for energy efficiency: 2005 / 2006

DK

Saving of energy:

The overall energy efficiency of this building is unknown. Calculated values estimate an energy saving potential of 31 kWh / m² / a without the savings related to the new heating system and the insulation of pipes. This means the saving potential results from the internal insulation measures, the insulation of the roof and the cellar as well as from the new windows.

Measures implemented:

The aim was to implement a high technical standard within the historic building to achieve lower energy consumption for room heating, hot water and ventilation. The apartments in the attic had been modernised.

The existing façade facing the street had to be preserved due to heritage preservation issues. The solid brick wall of the street façade had been well preserved in the past. Therefore just single damaged bricks were replaced. The existing windows in the walls to the street and to the backyard were insulated with internal insulation: The system consists of a timber stud frame with 100 mm mineral fibre insulation. The cavity between the timber stud frame was filled with mineral fibre insulation. To prevent air and moisture from penetrating into the insulation from the inside, an airtight shell was established. The airtight shell was established with a 0.2 mm polyethylene foil that also serves as the vapour barrier located on the warm side of the insulation. Joints

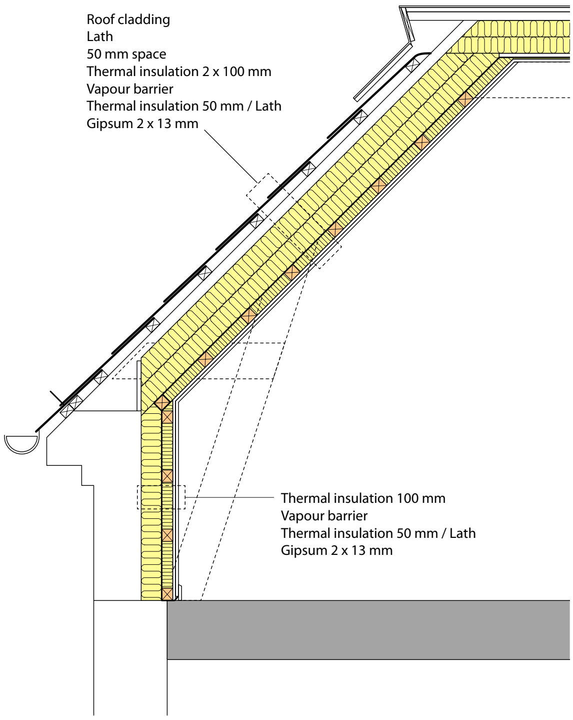
were airtight and securely fixed. The foil was brought to the exterior wall and fixed airtight by using a bottom rail.
Furthermore, the existing 45 degree angled double-pitched roof was replaced and insulated between the rafters with 200 mm mineral wool. No measures were implemented in the basement. The cellar ceiling with horizontal partition by timber beams are of a good quality with the dimensions 200 mm by 200 mm.

The single-leaf windows in the top floors within the flats were replaced by double-glazed window sealed units mounted in a Dannebrog formation frame due to heritage preservation issues. This was implemented in the street façade and the backyard façade.

The district heating system replaced the former heating system and the pipes in the basement were insulated. The prior heating system consisted of electrical heaters, all-night burners and paraffin heating systems in each flat. No measures were implemented concerning the ventilation system.

Special information:

The refurbishment was implemented after a previous engineering evaluation of the building. Afterwards, architects and engineers developed the project and supervised the implementation. The project was carried out completely by a building contractor. The refurbishment costs for this project are unknown.



Vertical section of the roof above the apartment in the former attic room.

LATVIA
Liepaja, Alejas Street 18

Year of construction: 1870

Architect: Paul Max Bertschy

Heritage status: –

Building type: Public building (art school)

Floor space: total area 1324 m², heated area 1290.5 m²

Implementation of refurbishment for energy efficiency: Planned in 2011

LV

Saving of energy:
The refurbishment of the building was planned in 2011. Therefore, the estimated energy savings are based on calculations. According to these calculations the energy consumption for space heating will decrease from 156 kWh / m² / a down to 98 kWh / m² / a after the refurbishment, which means a saving of around 60 %. But the calculated values are theoretical and not reality-tested.

Measures implemented:
The aim of the project is to increase the energy efficiency of the building. The existing brick masonry has been damaged by humidity in some parts. During the renovation the damaged bricks will be fixed as well as the parts of the joints which have been washed out by water over the years will be refilled. Furthermore, the outer walls of the 510 mm thick brick masonry will be insulated on the inside with 75 mm rock wool. A further measure is the insulation of the attic floor of the gable roof with 200 mm of soft rock wool. No energy-saving measures will be implemented in the cellar and the wooden beam ceiling. The windows were replaced some years ago by two-pane windows with a plastic frame, therefore no new windows will be installed. The heating system will be improved to modern qualifications by installing new convectors in the building and new thermostatic valves.

Special information:
The estimated refurbishment costs will amount to € 70,000.

LATVIA
Riga, Melnsila Street 7

Year of construction: 1907

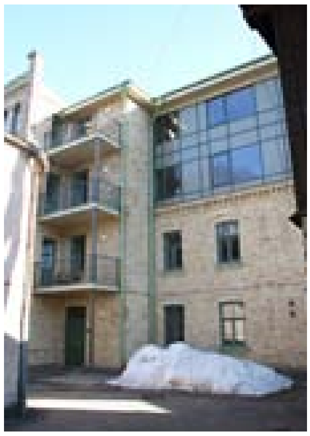
Architect: Jānis Alksnis

Heritage status: –

Building type: Apartment building

Floor space: total area 1110.1 m², heated area 1000.7 m²

Implementation of refurbishment for energy efficiency: Nov. 2005 – 2007



LV

Saving of energy:

The energy consumption of the building was not known or calculated. Therefore no statements about energy efficiency can be made.

Measures implemented:

The aim was a complete refurbishment of the building. In addition, a new glass construction was implemented on the backyard façade.
The 500 mm thick masonry didn’t exhibit any major problems. During the refurbishment the bricks in the façade were cleaned and the joints were refilled with materials that were similar to historic joints. Furthermore, the outer walls were insulated on the inside with 50 mm rock wool.
Further measures were the insulation of the attic floor of the gable roof with 300 mm rock wool. The wooden beam ceiling of the basement was not refurbished in an energy-efficient way. The foundation of the building was strengthen with reinforced concrete.
The windows were replaced by new double-leaf windows with a wooden frame.
The heating system was modernised by installing individual gas boilers in each flat.

Special information:

The refurbishment costs amounted to € 1.4 million.

LATVIA
Riga, Kr. Valdemara Street 1

Year of construction: 1876 to 1879

Architect: Johann Daniel Felsko

Heritage status: –

Building type: Public building (school)

Floor space: total area 6776.5 m², heated area 6544.9 m²

Implementation of refurbishment for energy efficiency: end of 2007 – Aug 2009

LV

Saving of energy:

The refurbishment for energy efficiency of the building decreased the energy consumption from ca. 122 mWh / month down to ca. 101 mWh / month from the heating system. This is a saving of around 20 %. The values are based on the real energy consumption of the building which was measured over one heating season.

Measures implemented:

The aim was a complete refurbishment of the building.
The brick masonry did not show any problems. The wall has different thicknesses, from 1344 mm on the ground floor, to 1063 mm and 931 mm on the top floors. All outer walls were insulated from the inside with 75 mm rock wool. A further measure was the insulation (200 mm loose wool) of the attic floor within the gable roof. No energy saving measures were implemented in the basement. The original double windows on the outer frame were renovated. The inner frame was rebuilt with new double panes. The heating system was replaced by a new system with new pipes and radiators. A new ventilation system with heat recovery was installed in all five air handling units.

Special information:

The refurbishment costs amounted to € 12.8 million.

POLAND
Gdansk, Grunwaldzka Street 186

Year of construction: 1890

Architect: unknown

Heritage status: Listed building since Dec, 2004 (No. 1753)

Building type: Military office building

Floor space: 2254.4 m²

Implementation of refurbishment for energy efficiency: 2007 – 2009

PL

Saving of energy:
The overall energy consumption was unknown before as well as after the refurbishment.

Measures implemented:
The aim of the project was to increase the energy efficiency of the building and the preservation of the original façade according to the requirements of monument protection rules. Therefore, parts of the outer walls which were not well insulated were insulated from the inside with 50 mm Epasit panels. The brick masonry is a two layer wall with a 60 mm air space in the basement and a one layer brick wall on the floors above the ground. In addition, parts of the outer wall were impregnated with hydrophobic materials to stop the infiltration of humidity to the inner side of the wall.
Further measures were implemented on the roof: The flat roof was covered with two layers of heat-weldable roofing membrane, the slope roof was covered with aluminium tin Prefalz. The roof was insulated between the purlins with 200 mm mineral wool. In the basement, the concrete calcium plaster was replaced by renovation plaster in those parts which are exposed to humidity.
The wooden single frame windows, mostly with two wings with openable top lighting, were restored. The heating system is a district heating system which was not changed during the refurbishment. In addition, a mechanical ventilation system with a fan coil air conditioning system was installed Aggregates located outside of the building deliver cool air into the building.

Special information:
None.

› Due to heritage preservation aspects, an external insulation is often forbidden on historic buildings because it destroys the original surface of a façade and changes the appearance of a building completely. ‹

b. Examples with external insulation

Only a few of the selected examples from the participating countries show measures taken on the outside of a building. Due to heritage preservation aspects, an external insulation is often forbidden on historic buildings because it destroys the original surface of a façade and changes the appearance of a building completely. Nevertheless, the connecting points between the surface of the façade and windows, doors or the roof are enormously affected. The following two external insulation examples from Germany were implemented in different ways. But one has to point out that this is not the normal way a refurbishment for energy efficiency of historic buildings is done.

GERMANY
Kiel, Hohenrade

Year of construction: 1938

Architect: unknown

Heritage status: no heritage protection

Building type: Apartment building (4 flats)

Floor space: 176 m² each side (352 m² overall before and after refurbishment)

Implementation of refurbishment for energy efficiency: completed

D

Saving of energy:

Before the refurbishment of the building the energy saving was estimated. These values were based on theoretical calculations. According to these calculations the energy consumption for space heating will decrease from 181 kWh / m² / a down to 71 kWh / m² / a for heat requirements. This means an estimated energy saving of around 60 %. But these values are calculated and not reality-tested. Furthermore, renewable energy is integrated into the concept: Solar collectors on the roof and a pellet heating system produce 60 % of the hot water demand and 10 % of the heat demand.

Measures implemented:

The aim was to refurbish one side of a semidetached house in an energy-efficient way in order to lower the energy consumption of the building. The refurbishment considered an expansion of flats under the roof as well. The building had not been destroyed during the second world war. The masonry was insulated with a 120 mm composite heat insulation system with attached brick slices of clay tile. The original masonry was preserved beneath the insulation system but the outside appearance was changed even though the brick slices were installed.

A further measure was the insulation of the ceiling of the basement with 60 mm plates of rigid foam 025. No measures were implemented for the roof. The windows were replaced by new three-leaf insulation windows. The existing heating system with a gas boiler was replaced by a pellet heating system with an 800 litre water buffer. In addition, solar collectors (10.5 m²) were installed on the roof. The system produces 60 % of hot water demand and 10 % of heat demand per year. The installation of a ventilating system is planned to be installed after the project is finished.

Special information:

The refurbishment costs were € 69,067 for one side of the semidetached house (€ 392 per m²).

GERMANY
Hamburg, Wilhelmsburger Str. 80–82

Year of construction: 1926 / 27

Architect: Wilhelm Behrens

Heritage status: Listed building since 12.01.1983

Building type: Apartment building, 16 flats, 20 flats after refurbishment

Floor space: 987 m², 1248 m² after refurbishment

Implementation of refurbishment for energy efficiency: 2010 – 2011

D

Saving of energy:

The energy saving potential was calculated before the project started. The calculation was based on theoretical values and adapted to the requirements of the German Energy Saving Act[1]. According to these calculations the energy consumption decreased from 215 kWh / m² / a down to 60 kWh / m² / a. That means an energy saving of 72 %, but this has not been reality-tested. In addition, renewable energy is integrated into the concept: Solar collectors on the roof heat the water for the heating system and for warm water supply. It is buffered in hot-water-tanks in the basement.

Measures implemented:

The aim was to implement a high technical standard to achieve the energy saving goals stipulated in the German Energy Saving Act. In addition, the building is located in the area of the International Construction Exhibition 2013 (IBA 2013) in Hamburg which has high aims as regards energy efficiency. In the attic, two more flats were added. Therefore the roof was removed and raised by about half a meter. At the same time, the façade to the street had to be preserved due to heritage preservation issues. So no measures were implemented on this brick masonry which has a 10 mm air gap. On the façade to the backyard, the original brick masonry, with plaster, was

1 Energieeinsparverordnung (EnEV)

insulated with an 18 cm composite heat insulation system and covered with plaster again.

In the attic, where the new flats were built, the roof was insulated between the rafters with 260 mm mineral wool. In addition, the wall to the street was insulated from inside with 100 mm mineral wool and an airtight shell with foil. The masonry to the backyard was insulated from outside with composite heat insulation.

The wooden beam ceiling in the basement had already been insulated with 100 mm mineral wool in an earlier refurbishment. Therefore no further measures were implemented at this point. The existing single and double-leaf windows were removed.

On the street façade, new two-leaf windows with mullions were installed due to heritage preservation issues. The windows facing the backyard were replaced by new three-leaf windows. The heating system was modernised. The existing gas-powered heating system in each flat was replaced by a condensing gas boiler. Hot-water tanks buffer the heat generation and consumption. In addition, solar collectors on the roof were installed for water heating and an air exhaust system was installed as well.

Special information:

The refurbishment costs are unknown. The property owners received special funding from the IBA 2013 (€ 40,000) in addition to existing funding from the federal government.

GERMANY
Hamburg, Sanitasstraße 20 – 26

Year of construction: 1924 / 25

Architect:–

Heritage status: Listed building since 21.09.1981

Building type: Apartment building (42 flats, 40 flats after refurbishment)

Floor space: 2616 m² before and after refurbishment

Implementation of refurbishment for energy efficiency: 2008 – 2010

D

Saving of energy:

The building has an energy consumption of 116 kWh / m² / a for a 10-flat apartment building after the refurbishment. Before the refurbishment it was up to 191 kWh / m² / a, thus it is an energy saving of around 64 %. These values are calculated and not reality-tested. Therefore we do not know exactly if measures on the outside of a façade really save that much energy.

Measures implemented:

The building is a listed building in Hamburg. Due to heritage preservation aspects, the façade to the street could not be insulated, the original brick façade had to be preserved. Because the joints of the brick wall were damaged in large parts over the years they were refilled with a material equal to the historic joint material. Furthermore, the gable of the building, which was completely damaged, had to be demolished and rebuilt. On the backyard façade, a composite heat insulation system was installed and covered with plaster. Further measures were: the repair of the roof and the insulation of the ceiling of the top floor; and in the basement the masonry and the floor was repaired. In addition, a damp-proof barrier was integrated into the masonry and the wall was made waterproof from the outside to keep away rising water. The windows were replaced by new insulating windows with mullions due to heritage preservation issues. The existing heating system (gas boiler) was modernised.

Special information:

The refurbishment costs amounted to € 2,616,000 (€ 1,000 per m²).

› In order to comply with aspects of heritage preservation, no external insulation is best because the façade will thus be preserved in its original form. ‹

c. Examples with no measures undertaken on the façade:

Most of the selected examples from the participating countries show buildings where no measures were undertaken on the façade in order to increase energy efficiency. In order to comply with aspects of heritage preservation, no external insulation is best because the façade will thus be preserved in its original form. Nevertheless, there is still great potential to refurbish historic buildings in an energy efficient way in the Baltic Sea Region.

ESTONIA
Tallinn, Pagari 1

Year of construction: 1912

Architect: Hans Schmidt

Heritage status: Listed building since 21.06.2005 (no 27436)

Building type: Apartment building

Floor space: 5527.8 m²

Implementation of refurbishment for energy efficiency: 2013

EST

Saving of energy:

Due to the fact that no energy efficiency measures will be implemented, the overall energy saving amount will be 10 kWh / m² / a per year for this building. The calculated estimate is that energy consumption will decrease from 292 kWh / m² / a to 282 kWh / m² / a, which means an energy saving of around 3.5 %. But these values are calculated, not reality-tested and seem not to be very high.

Measures implemented:

The aim is just to renovate the building. No measures to increase energy efficiency will be implemented because of the normal way historic buildings are refurbished in Estonia. By law, historic buildings can only be renovated in a conventional way in Estonia. The masonry does not have any construction problems. The wall is mixed stone and brick material. The outer walls are 980 to 1010 mm thick overall. The outer wall of the first floor consists of limestone; the inner wall is made of bricks. The third floor wall is made of brick and is 740-750 mm thick. The fifth floor wall is also made of bricks and still 630 mm thick. Because the walls are so thick, insulation of the façade would not significantly increase the energy efficiency.

The roof of the building is a wooden structure with gables, some parts are irregularly shaped. It will be demolished and rebuilt with a rolled zinc leaf which will cover the roof. The roof will be insulated by installing 260 mm mineral wool between the rafters. The roof will be raised 26 cm. The basement has a concrete ceiling which is insulated by 150 mm sand to the first floor. The existing two-leaf windows will be preserved due to heritage preservation issues. The inner windows will be upgraded with 14 mm glass packages.

The heating system is a central heating system which will be expanded by a mechanical exhaust ventilation system and fresh air valves.

Special information:

The renovation costs are unknown for this project.

GERMANY
Hamburg, Koreastraße 1

Year of construction: 1878 – 1879

Architect: Bernhard Hanssen and Wilhelm Emil Meerwein

Heritage status: Listed building since 2000

Building type: Warehouse

Floor space: 13,340 m²

Implementation of refurbishment for energy efficiency: 2006 – 2008

D

Saving of energy:

The overall energy consumption before the refurbishment is unknown because it was used as an unheated warehouse. The energy consumption is currently unknown. It will be evaluated after the heating period 2011 / 12.

Measures implemented:

The aim was to install a museum and its high requirements for the exhibits in this historic warehouse. The plan was to integrate a new heating system and domestic engineering system to create an appropriate climate in the building and low-energy consumption. The brick walls are a minimum of 800 mm thick, therefore there was no need to insulate them. Moreover, due to heritage aspects, it was not possible to insulate the historic walls. So only damaged bricks were replaced and maintenance was done on the joints. The roof was refurbished due to demands of the new usage and to support the special domestic engineering system. In addition, it was insulated with 180 mm mineral wool.

The basement provides space for the domestic engineering systems as well as the engine for the elevator after the refurbishment. Because the basement had been flooded regularly by the tides before the refurbishment, it had to be made waterproof.

Therefore a new layer of concrete as a "white" (i.e. without tar coat) basin was put onto the inner side of the original brick wall of the basement up to the ceiling of the basement.

In addition, the basement was filled in with concrete as weight to prevent an uplifting of the structure.

The original steel frame windows were maintained and a new frame with a single glass layer was installed on the inside of each window. A special feature is that the historic frames at the bottom as well as the new frames at the top are slit deliberately. Thereby the cold air is slowly warmed in the space between the window frames and slits as it seeps into the interior.

In combination with this measure, a floor-heating system was integrated in the new ground floor. The warmed air ascends to the roof and flows out. Thus, under-inflation occurs. Preheated air flows into the building from the leaky new windows and provides the interior with fresh air.

Special information:

The refurbishment costs for the whole project amounted to about € 28 million.

SWEDEN
Kalmar, Varvsgatan 20

Year of construction: 1865

Architect: Peder Knutsson

Heritage status: Not listed but wished to be preserved as part of old shipbuilding industry

Building type: Modern office building (former machinery workshop for shipbuilding and after that for the plastics industry)

Floor space: 712 m² after refurbishment

Implementation of refurbishment for energy efficiency: 2008

S

Saving of energy:

Through the refurbishment and the conversion of the usage of the building, the energy consumption decreased, according to the calculations, from 162 kWh / m² / a down to 121 kWh / m² / a. 74 % of power is from district heating, 27 % is from electricity and 9 % is from district cooling. The energy saving before and after refurbishment is 6 %. But these values are calculated and not reality-tested. In addition, renewable energy is integrated into the concept: The heating is performed by 100 % renewable energy.

Measures implemented:

The desire was to put in place a modern office building with a high technical standard and low energy consumption. The owner manages the property with great care for the environment. Systematic work with energy efficiency is the most important part of the environmental work of the company. There is a desire to optimise the use of energy and operational costs on an individual basis for every property, new buildings or existing buildings. When new buildings are built and the properties are developed, modern technologies with a high environmental profile are used and there is a desire to minimise the environmental impact through the right choice of materials, products and services. In the management of properties, the consumption of supply media is followed and analysed on a regular basis. The old brick façade had to be preserved in order to keep the impression of an old appearance of the building. The brick façade was worn and had some damage from penetrating water and frost blasting. The façade was repaired and single parts were exchanged where the damage was too severe. One lower part of the front façade was covered with plaster after an annex from the 1960s / 70s. This plaster was removed. The wall consists of 250 mm bricks, distance mat, 70 mm steel studs with isolation, and a 26 mm double layer of plaster (U-value 0.70 W / m²K).

In addition, the roof along with the roofing felt was insulated with 120 mm mineral wool on 200 mm light concrete (U-value 0.22 W / m²K). This building does not have a basement. The windows and the glass entrance were newly built (U-value of 1.4 W / m²K). The windows on the south and west sides received solar-protected glass with lower solar transmittance.The heating system is district heating with two ventilation systems: One is used for the ventilation of the floor, wall and roof construction due to emissions from the previous use of the building. The other system is used for common ventilation f with an FTX-system with rotating heat exchanger and a reheat efficiency of 80 %.

Special information:

The measures described are based on calculations with the energy calculation programme VIP+, including planned material in the building. In the programme, all used electricity goes to the building as heat. The energy need is calculated for every hour. The refurbishment costs are unknown for this project.

SWEDEN
Kalmar, Larmgatan 13

Year of construction: 1877 – 1900, rebuilt 1983 to flats

Architect: Hans Hedlund

Heritage status: Not listed yet but planned to be

Building type: Apartment building, old water tower (11 flats)

Floor space: 553 m²

Implementation of refurbishment for energy efficiency: 1983 and 2009 (new district heating)

S

Saving of energy:

The energy consumption of the building amounts to around 180 kWh / m² / a in a normal year. In 2009 there was a change from direct-acting electric heating to district heating with a comfort-related fee on heating and hot water. Earlier, every tenant had their own water heater in each apartment.

Measures implemented:

The building had no problems in regard to its 600 mm thick masonry. In 1983, flats had been built in the water tower. No energy efficiency measures had been undertaken on the façade because the walls are very thick. In addition, no measures were undertaken for the roof or in the basement. The windows had been integrated in the façade when the flats were installed. The heating system had been installed in 1983 as well.

In 2009 there was a change in the heating and in the heating of hot water from electricity to district heating. This increased the energy efficiency enormously. The heating system was changed and the tenants pay rent in accord with the improved comfort of heating and hot water. A certain amount of hot water is included in the rent. If the tenants use more, they have to pay, if they use less, they get money back.
21 degrees Celsius room temperature is included in the rent as comfort. For higher temperatures, the tenants have to pay extra rent.

Special information:

Although the outer walls are 600 mm thick, the tenants and owners have not had any problems with the condensation of water on the inside of the wall in summer. There are no heat or moisture problems in summer; just in winter some tenants think it is a little bit cold because of the wind and vulnerable location of the tower.

LITHUANIA
Kaunas, Pilies takas 1

Year of construction: 1852

Architect: Jokūbas Voleris

Heritage status: Listed building since March 2001

Building type: An old horse farm is to be reconstructed into public halls and apartments

Floor space: 2251.3 m²

Implementation of refurbishment for energy efficiency: in 2013

LT

Saving of energy:

The building was originally used as an unheated horse farm. The energy consumption of the building is currently not known or calculated. Therefore no statements about energy efficiency can be made. The building will be connected to the district heating system.

Measures implemented:

The aim is to implement a new use of the building. Public halls and apartments will be built and used as a so-called "Art Incubator" hosting five people as building administration staff and up to 350 visitors during public events. Therefore the foundation of the building will be restored, the basement as well as the brick masonry and the outer decorative row of bricks. In addition, the original windows, doors and gates will be authentically reproduced along with authentic architectural details (such as horse bas-reliefs, decorative elements etc.). The structure of the building will remain the same, after basic reinforcement measures and some reconstruction.

The brick masonry was in a good shape before the refurbishment but was damaged in parts of the foundation wall and the cellar. The capillary moisture is destroying the bricks because the rainwater gutters and drainage systems are malfunctioning. Therefore individual parts of the damaged brick masonry and of the outer decorative row of bricks will be replaced. In the cellar, parts of the base of the walls and decorative outer row of bricks will be repaired. The outer walls are 720 mm thick, therefore they do not have to be insulated.

In addition, the existing wooden beam roof will be reinforced and insulated with 250 mm mineral wool thermo insulation and the covering will be changed completely to authentic tiling. The original windows and gates will be restored if they are in a good shape, if not, new windows and doors will be reproduced from glued wood with double packed glass according to authentic examples, with a heat coefficient of 1.8 W / m²K. Moreover, a breathing ground layer will be installed around the whole perimeter of the building to prevent capillary moisture, and the rainwater system will be rebuilt.

The building will be heated through a central heating system after the refurbishment. The overall refurbishment costs are unknown. The construction work is partially sponsored by EU funds and by the Kaunas Region Municipality.

PL

POLAND
Czeladz, Kościuszki Street 18

Year of construction: end of XIX century

Architect: unknown

Heritage status: Listed building since 04.08.1992

Type of building: Apartment building (10 flats)

Floor space: 609.2 m²

Implementation of refurbishment for energy efficiency: 2009

Saving of energy:

According to the calculations of the U-value of the building, the energy consumption is 205.42 kWh / m² / a. This value is higher than the value calculated according to the Technical Conditions 2008 in Poland for buildings under modernisation (143.98 kWh / m² / a). The reason for this is that the Voivodeship Monuments Conservator in Poland forbids insulation on external walls. In addition, the Technical Conditions requirements do not have to be fulfilled for listed buildings.

Measures implemented:

The building is one of 12 similar buildings in the “Piaski” workers’ housing estate. This building had been destroyed by fire, only the foundations and the external walls survived. Finally, the decision was made that the foundations and external walls would be renovated without external insulation fulfilling the requirements of the Polish Monument Protection Law. The outer walls consist of brick and sandstone while the internal core walls are made of full brick and cement-lime mortar. The sandstone remained intact after the fire and was chemically cleaned. The façade to the north was in bad condition because two to four layers of brick were missing. All brick decoration elements were restored according to adjacent decorations. To repair the masonry, bricks were used which have a similar colour to the originals. About 30 % of the brick surface had to be rebuilt. (U-value

0.99 W / m²K). Further measures are the reconstruction of the wooden gable roof with roofing felt. The roof will be insulated with stone wool and steam insulation foil / damp insulation (U-value 0.22 W / m²K). The basement walls were dried and plastered again using refurbishment plaster. The basement wall is 750 mm thick and made from natural sandstone. It includes tenant's chambers, a boiler room and technical rooms. The ground floor will be insulated with floor expanded plastic slab, thereby the heat transfer coefficient of the ground floor is 0.32 W / m²K. In addition, the ceiling will be insulated with floor expanded plastic slab.
The wooden single-layer windows with internal window sills have to be rebuilt. The new windows in their shape and size look, from the outside, like the original box windows that were used in the past. The new wooden single windows with thermal insulation glass have a U-value of 1.1 W / m²K. The windows in utilised rooms are equipped with micro ventilation and humidity-sensitive window vents in the window frame. Roof windows will be used in the attic.
The heating system is fired by natural gas. The building has a natural ventilation because of the vents in the windows.

Special information:

The refurbishment costs are unknown at this point in the project.

POLAND
Lodz, Ulica Ogrodowa 17

Year of construction: 1878

Architect: Hilary Majewski

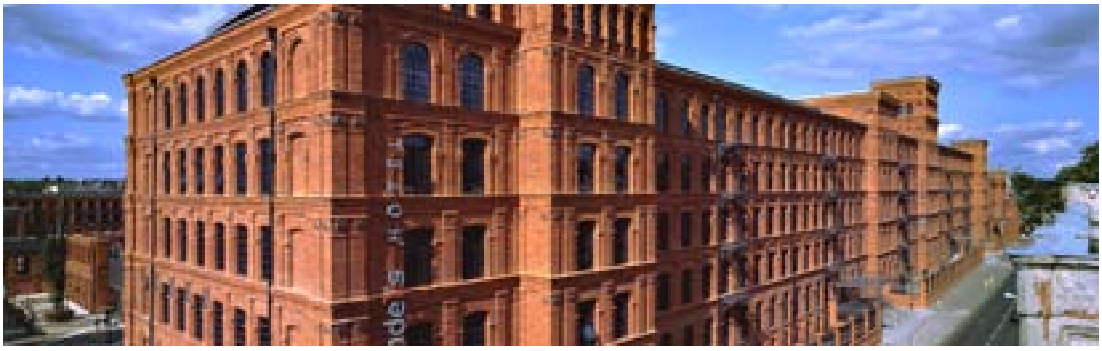
Heritage status: Listed building since 1970

Building type: Industrial building (cotton mill)

Floor space: 1248 m² (220-room hotel and 58 apartments)

Implementation of refurbishment for energy efficiency: 2007– 2009

PL



Saving of energy:

The overall energy consumption is unknown from before as well as after the refurbishment.

Measures implemented:

The aim of the project was to install a high-tech four-star hotel standard in the historic building, to achieve low energy-consumption and to use renewable energy sources. This had to be done within the requirements of heritage preservation rules while preserving all façades.
The existing brick masonry with wall dimensions of 400 to 1800 mm thickness was restored in the parts which had been damaged. The implementation of additional measures was not possible due to heritage preservation issues.
The flat roof was replaced by a completely new roof with a 200 mm mineral wool insulation (U-value = 1.5 W / m²K). In the basement, the brick ceilings were conserved, the cast iron beams were made fire-protected and a new finishing layer was installed on the floor. The single-glass windows in steel frames were upgraded with high thermal and acoustic insulation glass in respect of heritage preservation aspects (U-value: 1.5 W / m²K, 38 dB).

On the inside of the building, a central heating system was installed as well as an energy recuperation system for cold and warm air. A completely new ventilation and air conditioning system was also installed.

Special information:

The refurbishment costs for the whole project amounted to about € 75 million.

› This means that *in Poland* external insulation is forbidden for monuments with brick façades because of their historic and artistic value. ‹

d. Other approaches

In the following section the countries Poland, Belarus and Estonia describe how they normally undertake refurbishment for energy efficiency. Because of the monument protection laws, no or only limited insulation measures are allowed to be implemented in historic and protected buildings. Therefore, they give a short description of the way the refurbishment of historic buildings was or will be done in the buildings.

i. Poland Statement

In Poland, all heritage buildings, because of their historic, artistic or scientific value, are protected in the interest of society by the Monument Protection and Preservation Act of 23 July 2003. All work performed on immovable historic objects in the monuments register require approval from the Voivodeship (provincial) monument conservator. It must be in the form of an administrative decision allowing work to take place within the object according to discussed and approved regulations. This means that external insulation is forbidden for monuments with brick façades because of their historic and artistic value.

According to the Polish Building Law, Article 5 Paragraph 7.1, buildings that are subject to protection on the basis of monument protection regulations do not have to fulfil the requirements for Energy Performance Certification. This means that after the renovation is finished, even with internal insulation of external walls and approval for usage, the requirements for primary energy consumption according to the Technical Conditions 2008 do not have to be fulfilled.

As illustrated in the selected example from Poland, the architect made arrangements and guidelines concerning the energy efficiency of the historic building based on the above-mentioned conditions.

ii. Belarus Statement

The Republican Centre for Technology Transfer (RCTT), on behalf of the State Committee on Science and Technology of the Republic of Belarus, requested different organisations in Belarus to explain the methods and techniques used for refurbishment for energy efficiency in historic buildings.

For example, the PKUP “Minskprojekt” informed the RCTT that measures on the façades are performed without additional heat-insulation in reconstruction projects for historic buildings. No normal energy efficiency method was used for refurbishment in their projects. In addition, no analysis of the energy consumption in historic buildings was performed in Belarus. Therefore, the result is that in Belarus thermal rehabilitation of the envelope of historic buildings is not performed in practice. Consequently, data on energy consumption before and after refurbishment is not available for historic buildings in Belarus. Measurements and calculations of the energy consumption in historic buildings was not done.

The initial method used to calculate specific energy consumption along with the heat-and-power passport of buildings was introduced in the Technical Code of standard Practice (TCP) *Thermal protection of buildings–Heat-and-power characteristics–Identification rules*. This TCP came into force in September 2010. According to information from the PKUP *Minskprojekt*, the preparation of heat-and-power passports for buildings only began in September 2011. This means that up to the present no information about the energy consumption of historic buildings can be provided in Belarus.

iii. Estonia Statement

The National Heritage Board in Estonia holds the view that the protection of cultural heritage is a more important commitment than achieving a better level of energy efficiency in historic buildings. To provide the building with its original substance and appearance is more important than to save energy. Therefore, energy efficiency measures will not be actively implemented in historic buildings in Estonia and the heritage protection laws do not require listed buildings to be energy efficient.

The owners and developers of historic buildings also agree that the protection of cultural heritage buildings does not need to create additional value for energy savings. All parties in Estonia are aware of the worldwide necessity to save energy but momentarily the way historic buildings are handled will not change; until recently nothing was even done to find solutions which harmonise the demands of monument protection and energy saving.

In addition, interior insulation seems too risky at the moment: On the one hand, scientific research has not solved all the problems (e.g. condensate on the inside corner of the outer wall, the inner wall and the ceiling). On the other hand, it can be disastrous for the historic building and its cultural value if the builders make mistakes while implementing wrong energy efficiency measures.

The situation is changing since the end of 2011. Interest for solutions of energy efficiency in culturally valuable houses is growing, especially houseowners of old valuable houses, the Ministry of Economic Affairs and Communications, Heritage Board and Ministry of Culture of Estonia are interested. The growing interest is supported because of special supporting programms offered by Kredex, a state owned foundation, which implements renovation projects for energy saving.

› *The analysis of the cultural value* is needed for the preparation of the implementation of energy efficiency measures so that they suit the building and its individual features. ‹

3. Conclusions

After the presentation of the selected examples of the $Co_2olBricks$ project partners, the measures implemented will be evaluated in the following chapter. Besides the description of similarities and differences, the consequences of the project work, especially in Work Package 4 *Technical Innovations*, will be summarised. From this basis the necessary activities will be analysed and the next steps within the project will be prepared.

It has to be pointed out that the buildings described are examples which have been selected by the individual project partners. They do not necessarily represent the way the country always behaves in regard to refurbishment of historic buildings. Furthermore, the handbook focuses on the measures implemented for energy efficiency and less on the cultural value of the buildings. In an initial follow-up to the handbook, a summarised description of the cultural values of the examples should be presented.

Even though $Co_2olBricks$ concentrates on the aspects of energy efficiency, the cultural value has to be precisely defined. The cultural value has to be analysed in detail before the refurbishment. It is needed for the preparation of the implementation of energy efficiency measures so that they suit the building and its individual features. It has to be examined beforehand so that none of the measures will destroy the cultural value. Therefore the cultural value has to be evaluated before and after the refurbishment.

a. Similarities and differences

All selected examples show that every country deals very carefully concerning refurbishment for energy efficiency of historic buildings. It was difficult to find suitable examples from all the participating countries, therefore it became clear that a refurbishment for energy efficiency is only permitted in few cases. Generally, in all countries, it is normal to preserve a listed building in its original appearance and substance. Additionally, all selected examples represent individual solutions for refurbishing a historic building, not general comprehensive solutions. They may all be considered as experiments in the energy improvement quality of historic buildings and thus contribute in a small part to the growth of knowledge about refurbishment for energy efficiency.

As described in the introduction, listed buildings are normally exempt from obligations to improve their energy efficiency. But in the future it might become necessary for them to have quality energy efficiency because of the rising demands for climate protection. One of the measures used to mitigate the effects of climate change in industrial countries is the implementation of refurbishment for energy efficiency in historic buildings in order to reduce energy consumption and CO_2 emissions. Therefore the demands on the building stock are rising similarly to the demands on new buildings. To keep the historic buildings attractive and in use, they will have to reduce their energy consumption. Because of rising energy prices, historic and listed buildings have to be competitive.

It became clear that the energy efficiency measures implemented have to follow the requirements of heritage preservation. They have to fulfil the guidelines of the monument protection laws in the countries (see also interim results of Work Package 3). But as the examples and the different measures implemented show, what can be permitted is a matter of interpretation. Furthermore, for the implementation of measures it is very crucial to know which part of a building is protected and what status of protection it has. The cultural value has to be evaluated in detail before and after the refurbishment. Beforehand, a description of the cultural value has to be made in order to prepare for the implementation of energy efficiency measures and to define which parts of a building cannot be changed to comply with demands of energy efficiency and have to be preserved in their original condition.In order to enable discussions between policy developments and technical solutions, it is vital to know how different measures affect the heritage value of a building.
As the examples in Germany, Denmark and Latvia show, an external or internal insulation is possible under certain circumstances even on historic buildings; however, it is different in Estonia and Belarus: In these countries it is forbidden to insulate buildings from the inside or outside at all; in Poland it is forbidden only from the outside. The law does not permit insulation, especially on the outer walls. In addition, the implementation of measures depends on the interpretation of the monument protection officers in the different countries. What became clear is that even when an external insulation is permitted on a listed building, it is only possible under particular conditions. Before the refurbishment, the cultural value has to be defined in detail. For example, the measures implemented in Hamburg are only permitted because the insulation was done on parts of the building which are not visible from public space, on the façade to the backyard.

Furthermore, it became clear that the countries put the legal demands of energy saving into practice differently. For example, while in Belarus no energy passports at all had to be prepared for buildings until a new regulation passed in 2010, in Germany energy passports have been standard for buildings since 2008. Special regulations only for listed buildings allow them to be exempt from preparing energy audits. Even if historic buildings are presently exempt from the demands of energy efficiency, they might not be so in the future.

On the technical side, the examples show that a great number of the buildings are heated with convectors which heat the air. The air becomes the energy bearer. And this has consequences concerning the air temperature, the temperature of the surfaces of walls and windows and concerning the air moisture. In contrast to convector heating, there is the radiation heating system which is implemented in fewer cases. Therefore, the historic radiating heating system (in the past the tiled stove) is not taken into consideration for the implementation of heating systems in many countries. The radiation heating system works through a different physical principle: heat radiation. Heat radiation has many advantages for the preservation of historic buildings because the surfaces of walls and windows are heated and the air temperature is kept low. This means fewer moisture and condensation problems arise.

The usage of renewable energy is also below the average in the examples. Only a few buildings use renewable energy to reduce the carbon dioxide emissions. It is not integrated in the concepts, although it could be combined with other measures which are implemented in order to increase the energy efficiency enormously. Naturally, aspects concerning heritage preservation have to be taken into consideration. Furthermore, the examples show that in most of the cases mineral wool is the material which was used to refurbish historic buildings for energy efficiency. Calcium silicate panels or climate panels are used only in one example although they are capillary active and reduce moisture problems.

Nevertheless, the energy-saving potentials differ greatly. The amount of energy consumption cannot directly be connected to the measures implemented. Furthermore, the energy consumption of buildings in which no measures were implemented is not as bad as generally assumed. It must be said that all illustrated energy consumption is based on calculations and theoretical values and is not reality-tested–reality-testing could be a first step toward the development of new methods of refurbishment for energy efficiency.

b. Consequences

Overall it became clear that the refurbishments are implemented according to acknowledged technological rules. The measures implemented are all based on theoretical calculations of the heat transfer, energy consumption and energy saving potentials. No real values were gathered to form the foundation for implementation of measures on historic buildings. Furthermore, the calculations are done for single components of a building and do not provide a comprehensive concept for refurbishment for energy efficiency.

These calculations are based on empirical studies but are finally generalised and thereby again theoretical values. The calculations were made for the construction of new buildings; but historic buildings have completely different features. The values do not consider the individual features of the historic building and its components. They only provide general statements about buildings. But the individual features of a building are the crucial facts which have to be analysed before a refurbishment for energy efficiency can be implemented. Without an extensive analysis, the measures cannot be implemented in a correct way and thereby cannot provide the accurate energy-saving effects.

Furthermore, the measures implemented to increase the energy efficiency of historic buildings have to be evaluated after the refurbishment. It has to be clear what the exact effect of the measure is. How much energy can be saved in reality? Does the measure save as much energy as was envisaged in the theoretical calculations? Most of the refurbishments today are not evaluated in reality afterwards. Usually the theoretical calculations are trustworthy, but they cannot describe the reality. This has to be changed.

Besides this, it became clear that the cultural value is not presented in the examples as it should be. Before an energy qualification takes place, the cultural value of a historic building has to be defined in order to implement the right measures to save energy. The components which create the cultural value of the building must not be changed, demolished, or refurbished just for energy efficiency aspects. An analysis has to be done before and also after the refurbishment to determine the cultural value after the refurbishment for energy efficiency.
The following chart summarises the selected examples and shows measures which have been implemented:

Examples internal insulation						
Example	Frederiksberg	Hellerup	Alejas Street 18	Melnsila Street 7	Kr. Valdemara Street 1	Grunwaldzka Street 186
Country	Denmark	Denmark	Latvia	Latvia	Latvia	Poland
Building type	Apartment building	Apartment building	Apartment building	Apartment building	Public building	Military office building
Year of construction	1889	1904	1870	1907	1879	1890
Heritage status	Street façade is protected	Street façade is protected	_	_	_	Listed building
Insulation	internal	internal	internal	internal	internal	internal
New windows	yes	yes	yes, years ago	yes	yes	no
Roof insulation	yes	yes	yes	yes	yes	yes
Basement insulation	yes	no	no	yes	no	no
New heating system	yes (district heating)	yes (district heating)	yes (unknown)	yes (gas boilers)	yes (unknown)	yes (district heating)
Energy consumption	- 30 kWh/m² per year (calculated)	- 31 kWh/m² per year (calculated)	98 kWh/m² per year (calculated)	60 kwh/m² per year (calculated)	101 mWh per month in heating season (real values)	_

Examples external insulation

Example	Hohenrade	Wilhelmsburger Str. 80–82	Sanitasstraße 20–26
Country	Germany	Germany	Germany
Building type	Apartment building	Apartment building	Apartment building
Year of construction	1938	1927	1925
Heritage status	No protection	Listed building	Listed building
Insulation	external	external	external
New windows	yes	yes	yes
Roof insulation	no	yes	yes
Basement insulation	yes	yes	no
New heating system	yes (gas boiler & pellet heating)	New heating system yes (gas boiler & solar panels)	yes (gas boiler)
Energy consumption	71 kWh/m2 per year (calculated)	60 kWh/m2 per year (calculated)	116 kwh/m2 per year (calculated)

Examples with no insulation

Example	Pagari 1	Koreastr. 1	Varvsgatan 20	Larmgatan 13	Pilies takas 1	Kosciuszki Street 18	Ulica Ogrodowa 17
Country	Estonia	Germany	Sweden	Sweden	Lithuania	Poland	Poland
Building type	Apartment building	Warehouse	Office building	Apartment building	Farming building	Apartment building	Industrial building
Year of construction	1912	1879	1865	1900	1852	end 19th century	1878
Heritage status	Listed building	Listed building	Not listed	Not listed	Listed building	Listed building	Listed building
Insulation	no	no	no	no	no	no	no
New windows	no	no (upgrade)	yes	yes	yes (partly)	yes	no (upgrade)
Roof insulation	yes	yes	yes	no	yes	yes	yes
Basement insulation	no	yes	_	no	no	yes	_
New heating system	yes (central heating)	yes (district heating)	yes (district heating)	yes (district heating)	yes (district heating)	yes (natural gas)	yes (district heating)
Energy consumption	282 kWh/m^2 per year (calculated)	_	121 kWh/m^2 per year (calculated)	180 kWh/m^2 per year (calculated)	_	205 kWh/m^2 per year (calculated)	_

c. Necessary activities

In the industrial countries climate protection is becoming more and more important and measures to mitigate its effects have to be implemented. Therefore the demands for energy saving in the building stock have also increased continuously over the years. This means the historic buildings have to compete with the rest of the building stock. Faced with a background of rising energy prices, historic buildings have to address the reduction of energy consumption to stay attractive and in use. This happens for the new building stock every day. Therefore historic buildings might have to be energy qualified in order to contribute their part to saving energy. But for historic buildings we have to find the appropriate solutions which also preserve their cultural value.

Because of the results gathered from the collected examples, it became clear that $Co_2olBricks$ has to focus on real consumption values. The theoretically calculated values and promises should not be central; the project has to determine new processes for the preparation of refurbishment for energy efficiency. And even the evaluation has to become the focus of attention. Thereby a new quality can be implemented in the preparation of refurbishment for energy efficiency measures. The individual features of a building become more important and have to be considered. Nevertheless, over time the appropriate measures for the implementation of refurbishment for energy efficiency in historic buildings will become clear. And, last but not least, the costs for this sophisticated process of refurbishment have to be calculated and documented.

This means that before the refurbishment is implemented an extensive analysis has to be done: First, the different materials of the single components of the building must be sampled and examined. As regards the brick masonry, the real heat transmission and the water content of the walls has to be analysed. Therefore the water content, water absorption, salt content, compressive strength, etc., of the building materials have to be analysed. On this basis, with real values, simulations and calculations can be done and the right measures to increase the energy efficiency of the building can be selected. $Co_2olBricks$ defines any measure that decreases the energy consumption in a historic building as an energy-efficiency measure. This means that also the implementation of measures that do not alter the historic building itself are possible, for example a new heating system, the improvement of windows, basement ceilings and the roof as well as the

behaviour of the inhabitants. During the implementation phase the evaluation already has to be prepared. The effects of the measures should be examined and analysed for two or three years after the refurbishment.
In combination with this analysis, the cultural value has to be evaluated before the refurbishment as well as afterwards. It will be the basis for the decision about which building components can be refurbished due to the demands of energy efficiency and which determine the value of the historic building and have to be preserved in their original condition.

With these methods, a higher quality of refurbishment for energy efficiency can be achieved. Furthermore, the right measures, adapted to the individual features of the historic building, can be implemented. That means the energy consumption of the building can be decreased and the heritage preservation requirements can be fulfilled by implementing the right measures. Empirical inquiries can be developed on a large scale and an extensive evaluation will show in the future which measures are useful and which are not.

New processes have been added to the table below to complete the methods which guide the appropriate ways of a refurbishment for energy efficiency. It became clear that these analyses had not been done for the selected examples. The conclusion that can be drawn from this is that it is not done in many cases in practice. This is the point the project has to work on.

Examples internal insulation

Example	Frederiksberg	Hellerup	Alejas Street 18	Melnsila Street 7	Kr. Valdemara Street 1	Grunwaldzka Street 186
Country	Denmark	Denmark	Latvia	Latvia	Latvia	Poland
Building type	Apartment building	Apartment building	Apartment building	Apartment building	Public building	Military office building
Year of construction	1889	1904	1870	1907	1879	1890
Heritage status	Street façade is protected	Street façade is protected	–	–	–	Listed building
Insulation	internal	internal	internal	internal	internal	internal
New windows	yes	yes	yes, years ago	yes	yes	no
Roof insulation	yes	yes	yes	yes	yes	yes
Basement insulation	yes	no	no	yes	no	no
New heating system	yes (district heating)	yes (district heating)	yes (unknown)	yes (gas boilers)	yes (unknown)	yes (district heating)
Energy consumption	minus 30 kWh/m^2 per year (calculated)	minus 31 kWh/m^2 per year (calculated)	98 kWh/m^2 per year (calculated)	60 kwh/m^2 per year (calculated)	101 mWh per month in heating season (real values)	–
Material analysis	no	no	no	no	no	no
Real heat transmission	no	no	no	no	no	no
Evaluation after refurbishment	no	no	no	no	no	no

Examples external insulation

Example	Hohenrade	Wilhelmsburger Straße 80–82	Sanitasstraße 20–26
Country	Germany	Germany	Germany
Building type	Apartment building	Apartment building	Apartment building
Year of construction	1938	1927	1925
Heritage status	No protection	Listed building	Listed building
Insulation	external	external	external
New windows	yes	yes	yes
Roof insulation	no	yes	yes
Basement insulation	yes	yes	no
New heating system	yes (gas boiler & pellet heating)	yes (gas boiler & solar panels)	yes (gas boiler)
Energy consumption	71 kWh/m^2 per year (calculated)	60 kWh/m^2 per year (calculated)	116 kwh/m^2 per year (calculated)
Material analysis	no	no	no
Real heat transmission	no	no	no
Evaluation after refurbishment	no	no	no

Examples with no insulation

Examples	Pagari 1	Koreastraße 1	Varvsgatan 20	Larmgatan 13	Pilies takas 1	Kościuszki Street 18	Ulica Ogrodowa 17
Country	Estonia	Germany	Sweden	Sweden	Lithuania	Poland	Poland
Building type	Apartment building	Warehouse	Office building	Apartment building	Farming building	Apartment building	Industrial building
Year of construction	1912	1879	1865	1900	1852	end 19th century	1878
Heritage status	Listed building	Listed building	Not listed	Not listed	Listed building	Listed building	Listed building
Insulation	no	no	no	no	no	no	no
New windows	no	no (upgrade)	yes	yes	yes (partly)	yes	no (upgrade)
Roof insulation	yes	yes	yes	no	yes	yes	yes
Basement insulation	no	yes	–	no	no	yes	–
New heating system	yes (central heating)	yes (district heating)	yes (district heating)	yes (district heating)	yes (district heating)	yes (natural gas)	yes (district heating)
Energy consumption	282 kWh/m² per year (calculated)	–	121 kWh/m² per year (calculated)	180 kWh/m² per year (calculated)	–	205 kWh/m² per year (calculated)	–
Material analysis	no	yes	no	no	no	no	no
Real heat transmission	no	no	no	no	no	no	no
Evaluation after refurbishment	no	no	no	no	no	no	no

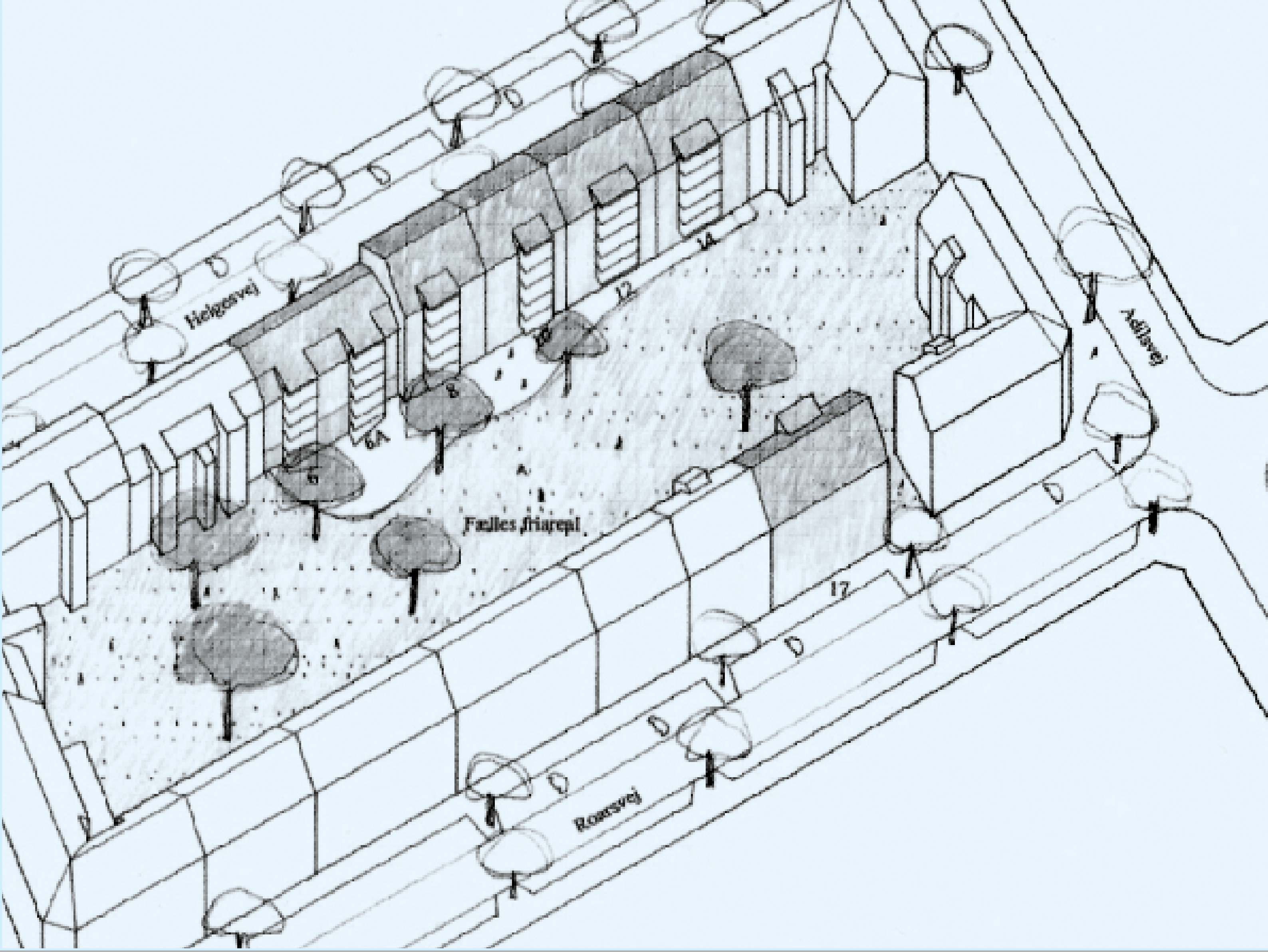
d. Next steps

This document is the first publication in Work Package 4 of the INTERREG project $Co_2olBricks$. It serves two purposes: On the one hand, all project partners were able to have a look into the different approaches concerning the aspects of heritage preservation and energy efficiency by studying the illustrated examples. In addition, the different examples have been discussed and lead on to a knowledge exchange. On the other hand, conclusions have been drawn which can guide the project partners to discuss new methods and implement them in reality.

In the next step of the project work, the project partners will start their research. As a result of this document the research has to be renewed and adjusted to the results of the discussion.

Photographs

Page 19:	Gdansk, Grunwaldzka Street | *GI Hossa S.A.*
Page 22:	Kiel, Hohenrade | *Dipl.-Ing. Jasper Harten*
Page 32	Hamburg, Koreastraße | *Denkmalschutzamt Hamburg*
Page 40:	Czeladz, Kościuszki Street | *Arkadiusz Kuc, www.fotopolska.eu*
	Magdalena Plocica, Mezzanino
Page 42:	Lodz, Ulica Ogrodowa | *Wallphotex, Op Architekten*



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