Co$_2$olBricks

Improving the Energy Efficiency of Historic Buildings

The four pilot projects of Co$_2$olBricks

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Preamble

This brochure, *Improving the energy efficiency of historic buildings – The four pilot projects of* Co_2*olBricks*, shows some of the results that have been gained by the Co_2olBricks work group *Technical Solutions*. This group was working to achieve its goals in the following four main areas:

- Research
- Best practice examples
- Technical solutions
- Pilot projects

The aim in general was to compile examples and results concerning energy-saving weak points and potentials of buildings with historical value. The four pilot projects, which are described in this brochure, have had the goal to implement, monitor and evaluate energy saving measures. The results gained within the first three areas are published in a separate booklet.

As in the whole project, also in the four pilot projects theory meets practice, meaning that the calculated energy efficiency measures were implemented and tested under real conditions in existing buildings. The aim was in each case to refurbish a historic building and to implement as many energy-saving measures as possible without destroying heritage values or, worse, damaging the whole historic structure. This implies that it was not the goal to save as much energy as technically thinkable. Commonly used as well as innovative methods have been chosen and implemented. The different experiences and results gained within the projects have been collected by each responsible project partner and the following chapters show a collection of their respective project-reports.

Within all pilot projects also some additional research has been conducted in order to address certain specific questions, concerning for example the effect of various internal insulation methods in different climates and different types of buildings or in combination with different heating systems. Further detailed information and results are accessible on the project website: *www.co2olbricks.eu*.

› The goal of the project was to identify measures by which the heat energy consumption, and hence the CO_2 emissions, of historic brick buildings can be reduced without destroying their historical value. ‹

1. Introduction

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, and by the end of 2013 it will have compiled the results in the main work groups: Policy Development (WP3), Technical Solutions (WP4) and Education and Economic Promotion (WP5).

The goal of the project was to identify measures by which the heat energy consumption, and hence the CO_2 emissions, of historic brick buildings can be reduced without destroying their historical value. For this purpose, 18 partners from nine countries 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. Also over 30 associated partners from all around the Baltic Sea supported the activities and results of the project. The partnership consisted of national and municipal heritage protection departments, universities, heritage protection organisations, vocational training institutions and energy agencies. The Lead Partner of the project was the Department for Heritage Preservation of the Ministry of Culture in Hamburg. Further information is accessible on the project website: *www.co2olbricks.eu*.

One of the main work groups was the group *Technical Solution*, in which the following 14 partners from 8 countries were involved:

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 NGO
GERMANY	Hamburg	Department for Heritage Preservation
GERMANY	Kiel	Environment Department
FINLAND	Helsinki	KIINKO Real Estate Education
LATVIA	Riga	City Development Department
LATVIA	Riga	Riga Technical University
LITHUANIA	Vilnius	Vilnius Gediminas Technical University

POLAND	Gdansk	European Foundation of Monuments Protection
SWEDEN	Växjö	Energy Agency Southeast Sweden
SWEDEN	Malmö	Environment Department

Almost every partner was working in at least two work packages. The following other partners of Co_2olBricks were active in different work groups:

GERMANY	Hamburg	Development and Environment Department
GERMANY	Hamburg	Vocational Training Centre
SWEDEN	Visby	Swedish National Heritage Board
SWEDEN	Stockholm	Stockholm City Museum

CONTRIBUTING TO A FLAGSHIP PROJECT OF THE STRATEGY

› Henceforth an approach is now pursed, at which town planning and political energy goal setting is steered through an integrated process of governmental standards as well as intensive information-sharing, co-operation and consultation by all parties involved. ‹

2. Model-reconstruction concept: Garden City 'Elmschenhagen-Nord', Kiel

**/ DIPL.-ING. STEFAN SALEH ARCHITECT,
DIPL.-ING. THOMAS HAHN ARCHITECT AND
DIPL.-ING. JASPER HARTEN ARCHITECT AND ENERGY CONSULTANT**

Figure 1: Row house, 'Kiel Elmschenhagen-Nord'

2.1 Origin and history of the project

Origin of the project 'Energetische Modernisierung der Gartenstadt Elmschenhagen-Nord' are the Climate protection activities of the City of Kiel. The climate protection concept of the city, set up in 2008, recognises the potential to reduce CO_2 emissions to 54 % by the year 2020, a. o. through the reduction of primary energy consumption and an increase in the share of regenerative generated energy (electricity and heat). The results of the Innovative Building Exposition (InBA) in Kiel in 2008 had a special role in this. The InBA was the German contribution to the EU Project REBECEE (Renewable Energy and Building Exhibition in Cities of the Enlarged Europe), which included a series of innovative and ecological building exhibitions in Middle and Eastern Europe. Within the concept of the InBA, passive-house standards were favoured, especially for new buildings. Subsequently these energy standards became part of the energy and climate-protection concept of 2008 as mandatory principle for town planning and for building and redevelopment measures, e. g. in civil planning and city building contracts. With the mandatory saving-standards set, the question was naturally posed, how the outer walls could be insulated by simultaneously preserving the brick façades, which are characteristic for the cityscape of Kiel. Henceforth an approach is now pursed, at which town planning and political energy goal setting is steered through an integrated process of governmental standards as well as intensive information-sharing, co-operation and consultation by all parties involved. In the garden-city ‘Elmschenhagen-Nord’ this process has been implemented as a pilot project for a number of years.

2.2 The Garten City ‘Elmschenhagen-Nord’

The settlement situated north of the B76 direction Lübeck/Plön is about 39 acres large. The ensemble is not heritage protected, but it falls under the ‘North German homeland design protection’ due to the use of bricks as typical regional building material. In the app. 130 two-storey townhouse lines with app. 1,800 units live app. up to 4,000 people. The consistent structure of the habitation area is characterised by the two storey townhouses in red-brick with joint and similar fashioned front gardens. Garden spaces are situated behind the town houses as well, interrupted by leafy footpaths as extra connection to the service roads. In the middle of the area, around the ‘Andreas-Hofer-Platz’, there are two-storey habitation and commercial complexes, built as special types but out of the same building materials. The buildings are divided by advancing fissures in the building line, a scaling of gables or special corner solutions. Furthermore there are stepped gables, archways at gangways and pergola designed elements as artistic elements of the house rows.

Figure 2: Binding land-use plan no. 974 ‘Kiel Elmschenhagen-Nord‘

The development of the area commenced in March 1939 by the Hamburger Settlement Building Society 'Herman and Paul Frank' for the navy. The architects Frank had already made experience with garden-city-settlements. Their garden-city-settlement in Hamburg Klein Borstel (1935–39) served the 'Nationalsozialisten' as exemplary settlement. In the 2^{nd} WW huge areas of the garden-city-settlement 'Elmschenhagen-Nord' were destroyed, and reconstruction continued up to the mid 1950's.

2.3 Modernisation approach

Due to the fact that the area does not fall under heritage protection it was decided to make appropriate regulations in the land development plan in order to maintain the quarter. The building-plan No 974 therefore contains specific requirements to preserve the stock, e. g.:

- Brick-red exposed brickwork
- Defined roof pitch for the main buildings
- Colour of the roof covering
- Consistent ridge and eave-lines

The building-plan is supplemented through a conservation statute, which prescribes further authorisation requirements for building measures and exceeding those of the state building code. To motivate homeowners in the area to comply with high energy standards, a special consultation and grant offer has been conceived. An essential component hereof was the development of a model reconstruction concept in advance. On this basis a fast and efficient support concerning the energy saving measures carried out by the owners could take place, ensuring as well the adherence of the design requirements.

2.4 Development of a model reconstruction concept

Within the development of the model reconstruction concept it was necessary to check if the InBA-standards, meaning at least the new building standard according to EnEV 2007, could be in principle implemented in residential areas with specific demands regarding heritage worthy design. Therefor the use of renewable energies became vital for the garden-city. For example the heat supply should preferably consist of 100 % regenerative energy. According to these specifications the previously set targets can be reached with the reconstruction models described below. Also model details were developed which fulfil the requirements of an up to date heat insulation with simultaneous consideration of the building-plan regulations.

2.4.1 The building types

The row-houses of the settlement are essentially composed out of the following fundamental types. The gable, resp. townhouse type 296 with two apartments and a mildly protruding oriel, represents the distinctive end type of a house row. It has an axle width of app. 5.5 m and a building depth of 8.12 m. This house row is completed with the townhouse type 60 comprising one apartment on a foundation of 4.22 m by 8.12 m. Whereas the Type 92, as middle or end house, has a building depth of 8.65 m. Beyond that special types with shops or access balconies are to be found in the centre of the town.

Figure 3: Row house type 296 and type 60, 'Kiel Elmschenhagen-Nord'

Due to its frequency the middle-house type 60 was chosen as basis for the model reconstruction concept. For this house various examples for heating and insulation were conceptualised in detail and also calculated in different variations. With this method insulation measures were developed for all parts of the building shell. Subsequently several possibilities of heating systems were reviewed. In the next step the thermal and technical characteristics of a compiled house row, comprising out of eight middle-houses type 60 and two gable types 296, was examined.

2.4.2 The building structure and its particularities

The residential buildings in the settlements are constructed in red brick and built with base, ground and upper floor. For this purpose they are bricked up on a substructure of concrete well rings which are connected with segmental arches on which the primary structures of the cellar outside-, middle– and building partition walls rest. The cellar outside-wall is sturdy with a thickness of 34 cm and the building’s base slab is made out of concrete with a thickness of app. 10 cm. Since the cellar only has a head room of 1.96 m a subsequent insulation of the base slab is complicated. One cellar-room was erected as an air raid precaution-room with exceptionally sturdy walls. Originally it was planned for a use with a toilet and a bathtub, for which there are cables underneath the base slab. The outer walls of the ground and upper floors are constructed as a double wall, on the outside an 11 cm brick, on the inside an 11 cm sandy limestone and an app. 6 cm wide air gap in between. All windows and doors possess an inner latch. The ceilings are made out of concrete and rest on the outer brick structure. The ceiling between ground and upper floor is connected with a massive joist to the outer wall and therefore interrupts the air gap. At this point a wooden-wool lightweight slab is placed on the inner side of the outer wall. This was designed as a lost casing and with a thermal buffer effect against condensation.

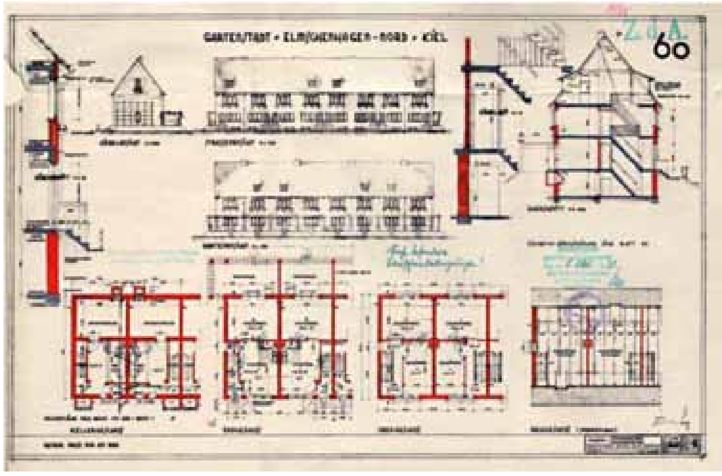

Figure 4: Row house type 60, ‘Kiel Elmschenhagen-Nord’

The purlin roof is erected from coniferous wood with rafters of about 8 x 12 cm and a pitch of app. 50 degrees. The existing small dormers show that this attic was original planned as an expansive reserve. On basis of the old existing plans from the year 1939 it was assumed for the model reconstruction concept that the two storey townhouse types share the same design. Restoration or reconstruction works in later years could partly have caused different constructions which were, however, neglected in the survey.

2.4.3 The energy standard-deficiencies

The buildings were erected quite sparingly, with simple structural constructions e. g. small wooden beams without any interior cover. The wooden framed windows were single glassed and therefore the weakest thermal point in the outer shell. Furthermore all salient components, for example the oriel, gable, flowerpot holders, outside stairs and so forth, were directly connected to the construction of the outer shell.

Because of the refurbishment work which has been done previously on most of the houses, comprising central heating systems and isolating synthetic windows, some structural physics conditions have been changed. Another problem was that for a renovation according to actual standards the building shell had to be energetically optimised and the thermal bridges and air leaks had to be eliminated. These steps would once again change the structural physics of the building components. Inappropriate modernisation could for example cause condensation on the thermal bridges. Furthermore it is also possible that faulty ventilation could cause mould formation on cold surfaces. Due to these reasons all measures are to be carefully balanced in advance.

The measures recommended in the framework of this model reconstruction concept were developed in detail on the basis of the calculations. They have to be checked and, if necessary, adapted for each building on-site. Normally this is done by a building physicist/energy consultant and/or architect/ engineer.

2.4.4 The energy analysis of the buildings

Computer aided energy analysis

On the basis of the on-site visits and available documentation a computer aided energy analysis was made. For this purpose the energy flows were determined on basis of the building's installation and technical data. These energy flows consist of the thermal losses through the building shell, especially windows, outer walls, storey-ceilings and roof surfaces, as well as ventilation losses and losses through the heating system resp. the hot water preparation. After determining the status quo in a next step the weak points were analysed and refurbishment-measures were suggested. The effectivity of the measures was judged on the energy-savings, the cost-effectiveness and the pollutant load. Thereafter further measures were suggested which were however, due to the variety and necessary efforts, not singularly valued in terms of energy-saving, cost-effectiveness and emissions.

Principally there are various approaches to make an energy diagnosis for buildings. The procedures differentiate mainly concerning the degree of details and in the consideration of the user behaviour. In this report the calculations which were executed were based on the DIN-Norms, the VDI Codes and the energy saving regulation EnEV 2009. The influences of the user behaviour were mostly disregarded in this method. This allows an evaluation of the pure structure as well as the installation system. Since nevertheless standard user behaviour is assumed it might be possible to draw conclusions about the user behaviour by comparing the calculated energy demand with the real energy use. All noticeable energy relevant circumstances and occurrences were, as far as it was possible, considered. If no evaluable data was accessible, empirical values for typical building and facility components of the respective building period were used. Therefore the stated costs and energy-savings are only approximate values and might differ from the actual conditions.

Thermography

Within the scope of the thermal analysis, a thermography of the building shell was made with a thermography camera. The pictures in figure 5 show the thermal conditions on the outer façade before the reconstruction (left) and after (right). For every singular pixel the thermal radiation was assigned to a temperature value with the help of an internal method of calculation of the IR-camera. This temperature range can be found in the colour palette on the right of every picture.

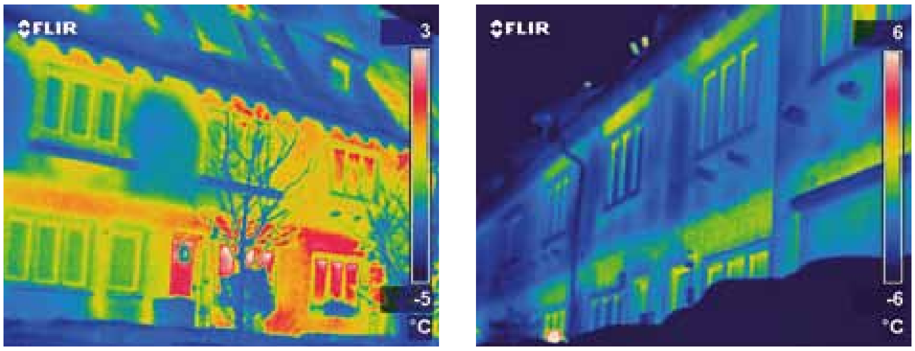

Figure 5: Thermography of the building envelope

In the refurbished building (right picture) the air duct in the outer wall was filled in with insulation; recognisable through the low temperature on the outer surface (blue). In the area of the bearing of the storey ceiling and the croppers and soffits of the windows the thermal radiation is significantly higher (yellow to red). Because these areas are compact and completed without an air duct, the thermal loss is rather significant.

Thermal bridges and air-tightness

Thermal bridges are areas in the outer building structure where the heat transfer is bigger than in the surrounding structural surface. The inner surface at thermal bridges cools down severely at low outer temperatures. Geometric and construction based thermal bridges cannot be completely avoided, even in well insulated buildings (e. g. outer wall ceilings). In the tested buildings especially the bearings for the flower boxes and the massive areas in the outer surface (scuncheons, croppers, ceiling structures) represented thermal bridges (see figure 5).

The air-tightness of the building shell also has a big influence on the heating requirements. An uncontrolled thermal exchange, e. g. through leaky joints and fittings, may considerably increase the energy consumption of a building. The compact structure of the tested building ensures already mostly the required air-tightness. Many roofs were already insulated in the 80’s, however not in a technically correct manner. Therefore generally no separate airtight layer (foil or similar) was implemented. In the further calculations a thermal exchange rate of $n = 0.7\ h^{-1}$ is assumed. The building ventilation through the users has been found to be ‘good’.

2.4.5 Development of modernisation variations

Based on the previously mentioned test results various modernisation variations were developed for which, apart from the provision of detailed structural sketches, the extents of energy savings as well as the investment costs were prognosticated in order to calculate the economic viability.

- Variation 1: Actual state
- Variation 2: Reference building EnEV 2009
- Variation 3: Cellar (insulation of outer walls and soles)
- Variation 4: Windows (replacement of windows and doors)
- Variation 5: Outer walls (core-insulation with polystyrene-granulate)
- Variation 6: Outer walls (core-insulation with nano-gel)
- Variation 7: Outer walls (thermal-insulation composite system)

- Variation 8: Ceiling (insulation of the top storey ceiling und slide-in stairs)
- Variation 9: Roof (insulation of the roof slopes with rafter reinforcements)
- Variation 10: Complete insulation + condensing gas boiler + solar thermal
- Variation 11: Complete insulation + wood-pellet heating
- Variation 12: Complete insulation + air-water heating pump

2.5 Executed reconstruction and further measures

The following results have already been achieved on the basis of the model reconstruction concept by May 2013:

- 103 Townhouse owners were advised
- 66 Owners have implemented energy saving measures (average investment of 2,500 € / townhouse)
- 3 apartment buildings (with 30 flats) were completely renovated by the owner 'FrankECOzwei-Gruppe' (100,000 € / building)
- Savings in energy of 360,000 kWh/year with these measures and CO_2 economisation of 72 tons/year

The advisory service given within the model-reconstruction concept will be continued in the future and supplemented with further services, like e.g. the execution of a hydraulic adjustment for the heating system.

Further documentation about the model reconstruction for the Garden-city Elmschenhagen-Nord is available on: *http://www.die-lernende-stadt.de/gruppe/quartiersprojekt-elmschenhagen-nord*.

Source: „Energetische Modernisierung und Baudenkmalpflege am Beispiel der Gartenstadt Elmschenhagen", H-architekten: Thomas Hahn - Stefan Saleh / Energieberatung: Dipl.-Ing. Jasper Harten, Kiel, 2010/11

› Communication between neighbours was initiated to achieve even better efficiency regarding energy consumption and cost-effectiveness by combining larger house sections. ‹

3. Pilot project 'Garden-City', Kiel

/ SUSANNE SIMPSON, JASPER HARTEN

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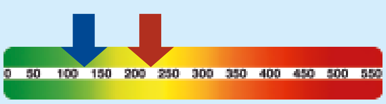
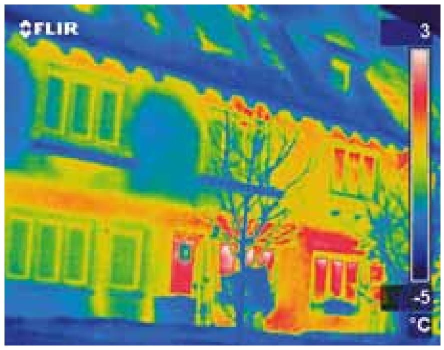
3.1 Project description

The garden-city 'Elmschenhagen-Nord' was constructed from 1939–1945 with 1,800 apartments for app. 4,000 inhabitants. As these buildings are not listed and mostly privately owned, advice was given to optimise refurbishing and energy saving measures. Therefore a master refurbishing concept was developed and measures were evaluated. Communication between neighbours was initiated to achieve even better efficiency regarding energy consumption and cost-effectiveness by combining larger house sections.



Address: Gebiet Elmschenhagen-Nord, Kiel
Building type: residential building
Architect: Hermann and Paul Frank
Year of construction: 1939–1945
Owner: mostly privately owned terraced houses and rental flats
Used as: residential building
Number of floors: 2–5
Façade: cavity wall, red brick façade
Floor space: 62 to 112 m^2 per unit
Cost of refurbishment: from 1,000 € to 30,000 € for an individual apartment

3.2 Strategy



Refurbishment

Start: 2011

End: 2012, still open for further owners, as they decide to start

Planer: Thomas Hahn, Stefan Saleh, Matthias Fiedler, Jasper Harten, Frank Andresen

Material

Façade: red brick cavity wall

Roof: concrete roof tiles

Windows: triple glazing, timber-frame with U-value 0.95 W/m²K, entrance door U-value 0.9 W/m²K

Shading system: none

Floor/Ceiling: concrete slab/timber

Inner walls: lime stone brick, external insulation U-value 0.2 W/m²K

Cellar: insulation regarding low headroom material

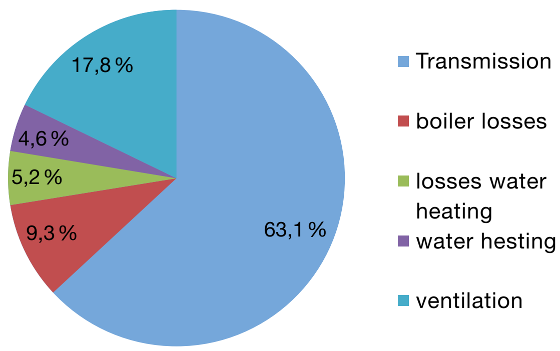
Foundation: lime stone bricks

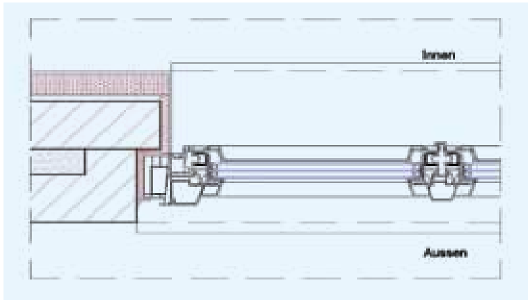
For long term quarter-preservation the city of Kiel set up a legally binding development plan regarding alterations e. g. of doors, windows and façades. Since 2010 a planning application and permission is mandatory for any alteration.

A master refurbishing concept was developed and measures were evaluated. An all-over insulation concept was aimed for and therefore the roof, walls, windows and cellar were examined to achieve best results on energy efficiency and design. The roof, an originally unfinished attic, acts nowadays as living space and needs improvement.

Design guidelines did not offer much assistance – a higher ridge line was not to be accepted. Therefor craftsmen installed insulation between the rafters and, when accessible, underneath towards the inside of the building, consisting of 12 cm mineral wool with a conductivity WLG 032. Technical difficulties arose from another layer of battens for the roof tiles which is mandatory because of German technical guidelines. The challenge of keeping the original ridge line was mastered by pure craftsmanship. Some cellars were excavated to install insulation from the outside. No measures were executed at the foundation and the inner walls. In the left photograph above the transmission heat loss is visualised: To the right the old existing façade and to the left a refurbished one. Four different measures were accomplished:

- Cavity wall insulation
- External insulation with brick-slip-finish
- Technical improvements
- Windows





Heating system / production

Old: central gas heating

New: gas condensing boiler or wood-pellet burner

Building services

Electricity: standard

Water / waste water: no measures

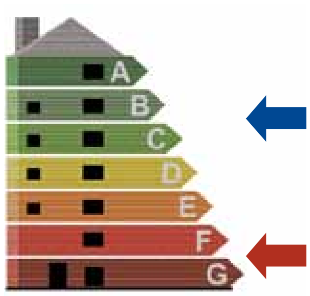
Energy consumption

Before: 202 kWh/m²/a

After, calculated: 173 kWh/m²/a

After, measured: no results so far

Energy saving: 15 % to 35 %



3.3 Wall insulations

The existing cavity of 6–7 cm in some of the buildings is filled with highly insulating polystyrene material (heat conductivity 0.034 W/m²K). As the construction includes thermal bridges, e. g. bearings for flower boxes and especially a concrete floor joining the outer masonry wall, there are areas of lesser performance. The energy saving is app. 14 %, including windows and doors. Other buildings (without a cavity between the brick layers) received a 14 cm insulation complemented with bricks slips and thus achieving a new U-value of 0.20 W/m²K. While technically easy to accomplish, highest efforts were needed to match the colour and size of the existing bricks. While the mortar colour is rather easy to match, it is extremely difficult to avoid joints which are too even. The visual impression differs. The energy saving is app. 35 %, including windows and door.

3.4 Technical improvements

The existing central gas heating can be replaced by more efficient installations. For buildings containing rental flats with higher energy needs it is recommendable to replace the appliances with highly efficient wood-pellet burners. Further measures include the fine-adjustment of the heat valves and a complete hydraulic compensation.

3.5 Window connection / conjunction

Specially designed windows were acquired to allow the assembling from the outside, as planned within this construction. Water tightness is achieved by compressed foam-tape.

3.6 Specials

The original elevations include flower boxes made of concrete and supported by concrete bearings which are built into the masonry wall. There is no binding plan concerning these elements. The recommendation is to dismount the bearings in order to avoid thermal bridges. Some owners developed their own boxes and new fittings.

3.7 Costs & financing

1. Costs	total costs (in €)
Cavity wall insulation	1,000
Windows, entrance door	7,500
Roof insulation: 4,000 € + roof cladding: 7,000 €	11,000
Basement ceiling insulation	2,000
Condensing gas boiler, incl. hydraulic compensation	7,000
sum 1	**28,500**

2. Financing	internal rate of return, interest rate (in %)	funding sum (in €)
Own money		na
Public funding: KfW	1%	26,800
Donations: Kieler Klimaschutzfonds		1,700
sum 2		**28,500**

3. Amortisation			
Heating cost before refurbishment	**energy use p.a. (in kWh)**	**cost per kWh (in €)**	**total cost p.a. (in €)**
Gas	18,000	0.08	1,440
Heating cost after refurbishment	**energy use p.a. in kWh (estimated)**	**cost per kWh (estimated)**	**total cost p.a. (estimated)**
Gas	9,200	0.08	736
Payback period for the refurbishment		**amortisation period (in years)**	**cost savings p.a. (in €)**
		28	704

1. Costs		total costs (in €)
Cavity wall insulation		1,000
Windows, entrance door		7,500
Roof insulation: 4,000 € + roof cladding: 7,000 €		11,000
Basement ceiling insulation		2,000
Wood-pellet burner, incl. hydraulic compensation		14,000
sum 1		**35,500**

2. Financing	internal rate of return, interest rate (in %)	funding sum (in €)
Own money		na
Public funding: KfW	1%	31,765
Donations: KfW (Effizienzhaus 115)		635
Donations: Kieler Klimaschutzfonds		1,700
Donations: Bafa (biomass)		1,400
sum 2		**35,500**

3. Amortisation			
Heating cost before refurbishment	**energy use p. a. (in kWh)**	**cost per kWh (in €)**	**total cost p. a. (in €)**
Gas	18,000	0.08	1,440
Heating cost after refurbishment	**energy use p. a. in kWh (estimated)**	**cost per kWh (estimated)**	**total cost p. a. (estimated)**
Wood pellets	10,000	0.05	500
Payback period for the refurbishment		**amortisation period (in years)**	**cost savings p. a. (in €)**
		26	940

Additional information:

- The amortisation period is calculated without the roof cladding

3.8 History and historical value

The garden-city 'Elmschenhagen-Nord' was built between 1939 and 1945 by the architects Hermann and Paul Frank which created a garden-city pilot project for Kiel. Nowadays 1,800 apartments with ca. 4,000 inhabitants form a lively quarter showing specific qualities but also the limits to modern living in elderly quarters.

The row houses are unlisted historic, not heritage buildings. When the decision for listing was due authorities realised the many changes in the quarter. There was no convincing possibility for conserving every single feature of the façades any more. So, in order to ensure long-term preservation, a legally binding land-use plan including design guidelines was developed. Since 2010 a planning application and permission is mandatory for any alteration. In order to achieve the best possible results and to optimise refurbishing and energy saving measures consultations, refurbishment concepts and individual advices are provided. Also communication between neighbours is initiated to gather measure for quality, results and cost effectiveness. As a model project the development profits from consulting and funding programs for energy efficient refurbishment of historical and monumental buildings developed by different institutions, e. g. the City of Kiel. The goal of the model project is to motivate and to support the house owners to implement highest energy standards.

On the base of the master concept individual consultations for owners offer information about improving the roof and the façades but also about additional energy-saving measures as cellar insulation and heating systems. During the last two years about 103 owners were consulted and 66 owners implemented measures. Single units and complete rows of houses were refurbished. Three apartment buildings were completely refurbished by the housing association 'FrankECOzwei-Gruppe'. Savings add up to 360,000 kWh per year, equal to 72 tons CO_2-reduction per year.

Aiming at keeping the brick façade for the quarter's quality, the construction of the buildings offers a cavity wall for implementing insulation. Appropriate energy-efficient windows and doors were installed. The purlin roof, originally with unfinished attic, poses challenges: As the development plan demands a fixed ridge height, implementing highest energy standards collides with the limitation in the height of the rafters. While modern techniques as solar thermal or PV is allowed, their implementation shows the need for regulation due to visual aspects concerning different mounting heights and styles on one roof area. A conflict lies in the fact that the quarter´s buildings are highly interesting for first buyers rather neglecting the structures demand for maintenance and energy consumption. Low energy budgets is a result of earlier investment and here the support programs can assist to reach a higher level of energy efficient refurbishment, especially within the limited options a historical house has to offer.

The implemented measures reduce the energy consumption:
- Cavity wall insulation minus 12 %
- Outer surface completely (wall, roof, windows) minus 54 %

Concerning the 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 applying water repellents correctly have to be developed in order to securely prevent rainwater from penetrating the outside wall and dampening the insulation. The façade should be in good state before cavity wall insulation is installed. Measures:
- New entrance doors, U-value: 0.90 W/m²K
- Cavity wall insulation:
  - Material polystyrene HK 35, hydrophobic
  - Water vapour diffusion resistance $\mu = 5$
  - Thermal conductivity: $\lambda = 0.034$ W/mK
  - Thickness of insulation = cavity 6–7 cm
  - Energy savings app. 14 %
  - Investment app. 8,000 €
  - Repayment time app. 5 years

3.9 Implemented measures and their energy saving effect

An alternative external insulation with brick-slip-finish is technically easy to accomplish, while highest efforts are needed to match the colour, size and assembly of the existing bricks. The results for 14 cm insulation finished with bricks slips, achieving a new U-value of 0.20 W/m²K, add up to combined energy savings of app. 35 % (including windows and door). The visual impression widely differs from the original. Specially designed windows were acquired to allow an installation from the outside as planned for this construction. Water tightness is achieved by compressed foam-tape. In order to optimise the heat performance the existing central gas heating can be replaced by more efficient installations. For buildings containing rental flats with higher energy needs it is recommended to replace the appliances with highly efficient wood-pellet burners. Further measures include the fine-adjustment of the heat valves and a complete hydraulic compensation which also leads to a better comfort.

3.10 Conclusion and lessons learnt

The results look promising

The model-refurbishment concept combines aspects of design, refurbishment and energy optimisation. It is an adequate means to consult owners, architects and craftsmen. An independent consultation is necessary to achieve energy optimised refurbishments. In Germany public funding is provided. The subsequent cavity wall insulation in double wall masonry construction is a cost-efficient, competitive and economic procedure. Before insulating the cavity the façade needs to be examined for damages. Brick and joint repair work can be required, especially at weather exposed elevations. After installing a thermal insulation and a condensing boiler system a hydraulic calibration for the heating-water system should be executed.

Execution of measures continues

It is still necessary for planning authorities to give basic and specific information on measures for owners and craftsmen. Individual consultation needs to be given for a long period of time.

Governmental assistance mandatory

The main requests for the future are: The design-guidelines fixed in the binding land-use plan have to be adapted to technical requirements, e. g. ridge line elevations when roof insulation applies. Regarding these design guideline, easily understandable and accessible information for owners and craftsmen have to be provided. The model-refurbishing concept has to be set up in a way that it can be altered in order to conform to future energy regulations (German EnEV 2014).

CONTRIBUTING TO A FLAGSHIP PROJECT OF THE STRATEGY

› Therefore state of the art materials for building refurbishing, like aerogel mat and vacuum insulation panels for wall insulation, were chosen. ‹

4. Pilot project 'Information Centre', Riga

/ MĀRTIŅŠ MENNIKS

LV

4.1 Project description

The investigated building is located in the historic city centre of Riga (state urban monument protection No. 7442) and also listed in the UNESCO World Cultural and Natural Heritage Site – Historic Centre of the Riga territory (protection No. 852). Originally built as a public restroom it was without any use and unheated for the last years and therefore in bad state, a. o. cracks in the walls.

Address: Maskavas street 8, Riga
Building type: silicate brick building
Architect: unknown
Year of construction: 1930
Owner: Riga City Council
Used as: not used
Number of floors: 1
Façade: painted silicate brick
Floor space: 64.8 m²
Heated area: 61.8 m²
Cost of refurbishment: ~ 150,000 €

4.2 Initial situation

The building has not been used for some years. Therefore it was in a very bad state before the renovation. All building shell elements have been damaged in one or the other way; for example cracking walls, disintegrating brick masonry, and windows with broken glass panes.

4.3 Possible technical solutions

The possible energy efficiency measures include new windows and doors, thermal insulation on inner walls, the floor and ground and the ceiling/roof. Furthermore energy efficient lighting and electrical equipment have to be installed.

4.4 Motivation to select the specific measures

The aim is to decrease the energy consumption of buildings with historical value and to show different materials for energy efficiency improvements. Therefore state of the art materials for building refurbishing, like aerogel mat and vacuum insulation panels for wall insulation, were chosen. Also windows with triple glazing and integrated shading have been installed.

4.5 Planned measures

The following measures are implemented in the building:
- Walls insulation from inside using aerogel mat, PIR, VIP
- New windows with integrated shading
- Insulation of floor and ceiling
- Artificial lighting with LED
- Self-cleaning paint on outer façade

4.6 Explanation of process

The aim of this project is to show the technical possibilities for building renovation. After renovation the building will be used as an example for reconstruction of brick buildings and as a tourism, culture and information centre. Therefore all the implemented measures will be visible through glass panes.

Refurbishment

Start: 2012
End: 2013
Architect: na

Material

Façade: brick
Roof: metal
Windows: wooden frames triple glazing
Shading system: between the glazing
Floor: tiles
Ceiling: wooden
Inner Walls: wall board

Heating system / production

Old: electric heating
New: district heating, electric heating

Building services

Electricity: new
Building automation: partly automated
Water / waste water: new installation

Energy consumption

Before, calculated: 671 kWh/m²/a
After, calculated: 134 kWh/m²/a
Energy saving: 80 %
Adress: Maskavas street 8, Riga
Building type: Silicat brick building
Architect: unknown
Year of construction: 1930
Owner: Riga City Council
Used as: not used
Number of floors: 1
Façade: painted silicate brick
Floor space: 64.8 m²
Heated area: 61.8 m²
Cost of refurbishment: ~ 150,000 €

1. Costs	total costs (in €)
Site preparation-maintenance costs	3,262.85
Dismantling works	4,885.24
Foundation, waterproofing reinforcement	22,624.46
Floor plate	7,880.28
Wooden floors	4,696.29
Roof, roofing	6,709.28
Walls, partitions	9,605.88
Internal decoration	8,547.89
Facade renovation	8,722.34
Windows, doors	14,873.34
Miscellaneous works	1,756.44
Equipment	5,112.89
Heating	3,125.26
Heat pump	10,681.97
Ventilation system	7,281.62
Water sewerage	2,132.28
Electrical installation works	10,809.95
Alarm system	567.71
Computer network	618.19
sum 1	**133,894.16**

2. Financing	internal rate of return, interest rate (in %)	funding sum (in €)
Own money		20,084.12
Bank credit		na
Public funding	0	113,810.04
sum 2		**133,894.16**

3. Amortisation			
Heating cost before refurbishment	**energy use p.a. (in kWh)**	**cost per kWh (in €)**	**total cost p.a. (in €)**
Calculated energy consumption from district heating	37,830	0.07	2,670.80
Heating cost after refurbishment	**energy use p.a. (in kWh) (estimated)**	**cost per kWh (estimated)**	**total cost p.a. (estimated)**
Estimated use of electricity for powering air-water heat pump (COP=3)	2,522	0.15	383.3
Payback period for the refurbishment		**amortisation period (in years)**	**cost savings p.a. in €**
		58.5	2,287.50

4.7 Costs & financing

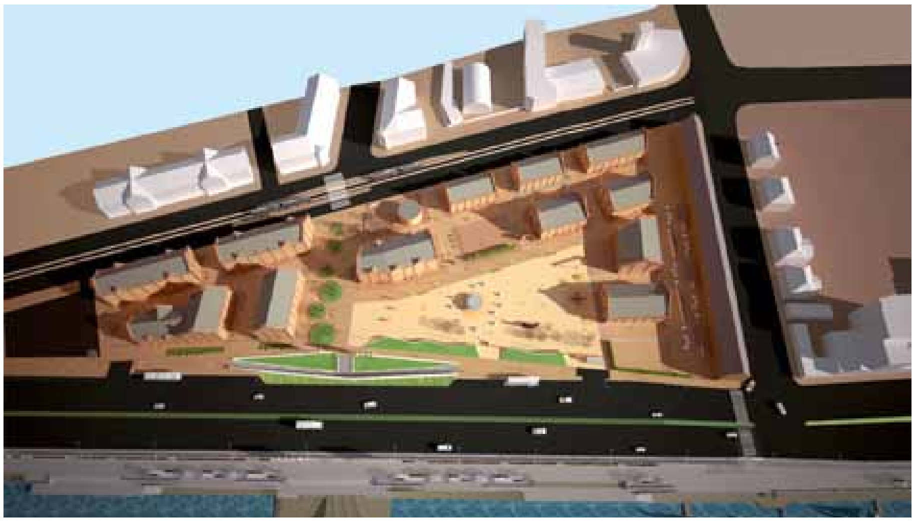
The payback time of the pilot project is very long and exceeds the lifetime of the implemented energy efficiency measures. We think that it is appropriate for this kind of a project because it is not a simple project where the only thing that is taken into account is the economic feasibility. The aim of this project is to provide new knowledge on refurbishing historical buildings. The knowledge gained in this project can be used in further building renovation projects as well as for the improvement of the competences of owners and craftsmen. The usage of the building will be changed after the refurbishment and the energy consumption is based on calculated figures. Until now the main and only use of the building was as a public toilet. After the refurbishment the building will be used as an example for brick façade building's reconstruction and as a tourism, culture and recreation information centre with facilities for the visitors.

4.8 History and historical value

The investigated building is located within the Spikeru block between Maskavas, Turgeneva and Krasta Street and it is located in the historic city centre of Riga (State urban monument protection No. 7442). The site is also listed in the UNESCO World Cultural and Natural Heritage Site - Historic Centre of the Riga territory (protection No. 852).

The Spikeru block is located in the area where the Riga Central Market has been installed in the sixties, seventies and eighties of the 19^{th} century after the removal of the Riga fortress. The warehouses block was built after the plans developed by the most prominent architects in the Riga at that time - Roberts Augusts Pflugs, Karlis Johans Felsko, Janis Fridrihs Baumanis and Reinholds Georgs Smelings. Today only 13 of those buildings have remained.

The building of the pilot project at Maskavas Street 8 was erected in 1930 just after the completion of the most modern market place in Europe at that time. At the beginning it was used as the post for the policemen and the market's local control, but very soon the building's functions were changed to a toilet and a small technical warehouse. From the architectural point of view it has a very important historical value because it is considered to be one of the first silicate brick buildings in Riga. No other significant silicate brick building has been found in Riga's historical centre so far. After the 2^{nd} WW the building was rebuilt for the use as a public toilet in the Central market (1948–1950) and used until 2000. Then, because of pure technical reasons, it was closed and conserved in a basic manner. Demolition was rejected by the state heritage preservers but the reconstruction was postponed till the reconstruction of whole Spikeri warehouse district started.



Urban development plan (source: Riga City Development department, Architect: Ltd."ARPLAN")

After the Ministry of Environmental Protection and Regional Development Board had approved the financing of the reconstruction of the Spikeri warehouse district (in 2009) the City Council approved the co-financing for the reconstruction of the Maskavas 8. At that time it was meant to comprise the reconstruction of a brick façade building for the purposes of an information point. Later the idea was supplemented with the concept of servicing as an information centre for culture, tourism and recreation within the warehouse district – similar to the wooden building reconstruction and tourism information point in the newly renovated wooden building in the historical centre of Riga.

4.9 Measures done and the energy saving effect

The pilot project is a common idea and the project of several institutions:

- Riga City Development Department (project management)
- Riga Technical University (technical and intellectual support)
- Chief Architect Office of the Riga City Council (historical and architectural information and other support)
- East District Council of the City of Riga (main benefit recipients, owners of the project idea)
- NGO "Development of the Spikeru warehouse district" (planning)

In this partnership the ideas were developed and the financial support for the after investment period and maintenance of the building, which will function as the information point for the brick façade building reconstruction and tourism, culture and recreation information centre for the district, was raised.

There is no measured heat energy consumption data available for this building since it was not heated for some years prior to renovation. Detailed calculations were made in order to estimate the energy consumption for space heating in this building. These calculations show that the building will consume 37.8 MWh of energy when heated for the whole cold season. The building has a high energy consumption because the heat transfer coefficient for the building shell is very high (the measured heat transfer for the walls shows that it is 5 times higher than it should be according to the Latvian Building Code) and the building itself is very small (the smaller the building the bigger the specific heat consumption).

Savings from implementing energy efficiency measures were calculated based on the calculation model. These calculations show that heat energy consumption will be reduced by 80 %, which means that the energy consumption in this building will be 7.56 MWh per year after implementing the energy efficiency measures. The specific energy consumption for space heating will be lowered from 671 kWh/m^2/a to 134 kWh/m^2/a. After the renovation the building will be heated by using an air-water heat pump. This means that the actual consumption of electricity will be even lower. Using an assumption that the heat pump will operate with COP (Coefficient Of Performance) equal to 3.0 it was calculated that the consumption of electricity for heating this building will be at 2.52 MWh per year or 45 kWh/m^2/a.

The selected measures to achieve these goals are:

- Reconstruction of existing floor structure and cover, wall cladding, partitions, doors, windows, roof support structure, the roof deck and the dismantling of the settlements
- Opening of the base and enhancement of existing foundations — repair and reinforcement, under the existing foundations constructing concrete with paling, waterproofing of foundation
- New floor construction
- Roof deck covering to be built, new tin roofing and rainwater drainage systems to be built; construction of ventilation channels
- Façade renovation – the existing brick wall restoration, brick replacement to equivalents bricks, brick priming and painting; reconstruction of the entrance porch
- Wall insulation from the inside, floor and roof insulation (roof) in 4 divisions
- Replacement of the windows, the front pad and doors
- Individual heating and ventilation system
- New plumbing installation like internal water supply and sewage network
- Installation of internal wiring, lighting network and lightning protection systems
- Installation of internet and telephone for network of security alarm, fire alarm, computer networks and video surveillance systems

The exterior wall inside-insulation is planned with three different types of insulation materials. This will be done in accordance with the architectural plans where there are specified the distribution of insulation materials between two different thicknesses of layer.

Wall insulation materials are installed between the wooden vertical slats. For exterior wall insulation there will be used following insulation materials (or equivalent):

- Polyizocianurate (PIR) of Recticel Insulation Eurothan GP, b = 100 mm (insulation sheets with aluminium foil coating, thickness of 100 mm, 1,200 x 2,400 mm, installed in one layer with 100 mm, the material is allowed to be cut)
- Aspen Aerogel-Spacelof Classic, b = 50 mm (insulation material of roll system with a width of 1475 mm and a thickness 10 mm, installed with five layers of 10 mm each, the material is allowed to be cut)

- Vacuum insulation panels „NanoPor VIP „, b = 50 mm (closed panels with a thickness of 25 mm, 600 x 450 mm, installed in two layer with 25 mm each, the material is not allowed to be cut, pierced or exposed to mechanical loads, it is prohibited to place objects or walk on it)

The floor is equipped with polyizocianurate (PIR) of Recticel Insulation Eurothan GP, b = 200 mm or equivalent (insulation sheets with aluminium foil coating, thickness of 100 mm, 1,200 x 2,400 mm, installed in two layer with 100 mm, the material is allowed to be cut). For the ceiling polyizocianurate (PIR), Recticel Insulation Eurothan AL, b = 300 mm, or equivalent (insulation sheets with aluminium foil coating, thickness of 100 mm, 1,200 x 2,400 mm, installed in three layer with 100 mm, the material is allowed to be cut) was used. Before the installation of roof decking there will be insulated steam isolation film (SIG-5 or equivalent Majpell).

The main basis for choosing the measures was the onsite measurement of the energy efficiency of the building and the calculations made by the experts from the Riga Technical University. The chosen technical solutions were based on the competence of experts and on the necessity to gain experience in using innovative and rarely used materials in Latvia in local conditions. We consider that the materials chosen for this kind of building will be a good example and will help to gain great competence in this field not only in Latvia, but in the whole Baltic see region. Specific materials still need to be tested to be sure that they will bring maximum results.

4.10 Conclusion and lessons learnt

This pilot project showed that the energy efficiency level of historical buildings in their un-renovated state can be very low. The energy consumption in this type of buildings can be reduced significantly without affecting the appearance of the building and lowering its historical value. By using innovative insulation materials and solutions it is possible to reduce the building's energy consumption by 80 %. The costs of this kind of renovation are higher than for a typical renovation of a non-historical building. This project should be viewed as a pilot project where the aim was not only to do an economically feasible renovation and refurbishment work, but rather to push the boundaries of the existing knowledge and existing experience about the energy efficiency of historical buildings. This renovation is state of art not only for historical buildings but also for buildings as such.

Detailed measurements that will be carried out after all energy efficiency measures are implemented will show the real energy savings. With the measurements it is planned not only to investigate the heat energy savings but also to monitor how these energy efficiency measures have affected the indoor air quality. We hope that this pilot project will open doors for a new thinking on energy efficiency in historical buildings and will be the first step towards more efficient and sustainable buildings cross-sectoral. From the legal and technical point of view we found several issues that we need to work on at local level. First of all the preparation of the technical specification for the procurement of the technical project had to be made. It took some effort to work with the state institutions which are issuing the technical rules. The main problem is the failure to understand the specific goals of the project regarding the need for innovative solutions in order to reach the two main aims – the reduction of the energy consumption and the protection of the historical architectural values. During the development process of the technical project the main difficulty was the lack of competences and experiences from the architects and engineers, so that we needed to integrate the experts from the RTU.

Currently, at the phase of the procurement of the construction, there are a lot of questions concerning the materials chosen within the project because, as it was mentioned previously, they are innovative and mostly unknown within the local market. This is considered as a great risk because there will be a need of a total supervision of the construction process from the experts who know the technical parameters and instructions for the use of the materials. Riga City Council needs to admit that the help from the Riga Technical University was crucial to reach this point because it is essential to point out the lack of knowledge in this sphere not only for the project managers and technical personal in Riga City Council but also in the whole construction sector in Latvia. Riga City Council admits that for future projects it is necessary to attract only the best experts and for this we hope on the dissemination of the results achieved in RTU.

CONTRIBUTING TO A FLAGSHIP PROJECT OF THE STRATEGY

› In two units, one with wall heating and one with convector heating, indoor and outdoor temperature and humidity at several points in the construction and the heat flow will be monitored. ‹

5. Pilot project 'Holstenkamp', Hamburg

/ JAN PRAHM

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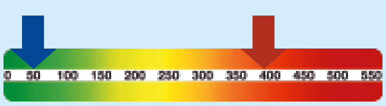
5.1 Project description

The building is a former old people's home situated in Hamburg-Altona. The ensemble consists of 8 brick buildings which are symmetrically arranged around a green park area. Two of the buildings are two storied and have a hip roof, the rest of the buildings are single storied with a hip roof. The buildings are in a good technical condition and under heritage protection.



Adress: Holstenkamp 119, Hamburg
Building type: old people's home
Architect: unknown
Year of construction: 1922–23
Owner: joint building venture "Hütten und Paläste"
Used as: residential building
Number of floors: 2 to 3
Façade: brick
Floor space: 3.900 m²
Heated area: 3.300 m²
Cost of refurbishment: 173,600 €

5.2 Initial situation

Refurbishment

Start: March 2013
End: October 2014
Architect: Heyden und Hidde, Hamburg

Material

Façade: brick and sand-lime brick
Roof: clay tiles
Windows: wood in façade, aluminum / wood in roof
Shading system: sun protection glazing, canopy or jalousie
Floor/Ceiling: concrete, wood
Inner Walls: sand-lime brick
Cellar: brick and sand-lime brick
Foundation: brick

Before the refurbishment the building had been empty for some years and prior to that it had been used as a residential accommodation for difficult-to-educate teenagers. The City of Hamburg owned the land and the buildings and wanted them to be used by a joint building venture. In a selection process between several competing groups one was selected and is now implementing and financing the refurbishment. The owners are a group of 29 different parties who commonly own the buildings.

5.3 Possible technical solutions

The following measures were regarded as generally speaking possible in this specific building:

- Walls: Internal insulation of the outer wall with capillary active material
- Floors: Insulation of the under surface of the floor
- Roofs: Insulation of either the top floor or common rafter insulation
- Doors: The original ones still existed but because they were in a very bad state it was allowed to replace them.
- Windows: They were not original anymore, therefore exchanged with more energy efficient ones, made from the original material wood and with the original division by glazing bars
- Heating system: Replacement with a new heating system, but no solar panels on the roof
- Mechanical ventilation system: A ventilation system that uses the existing chimneys, no core boring into the outer walls would have been allowed
- Electric system: Will be renewed completely because it is not original and in a very bad state

Heating system / production
Old: probably oil
New: combined central heat and power generation with natural gas

Building services
Electricity: all new
Building automation: heating control, ventilation with heat recovery
Water: normal supply by network
Waste water: leeching cesspool

Energy consumption:
Before, calculated: 387 kWh/m²/a
After, calculated: 48 kWh/m²/a
Energy saving: 86 %

5.4 Motivation to select the specific measures

Within Co_2olBricks three houses were equipped with wall heating systems and internal capillary active insulation while the other 5 houses will be equipped with convector heating and an internal capillary active insulation. Because the inner sides of the walls are not of heritage value, it was possible to apply internal insulation and a wall heating.

The internal insulation and the wall heating were chosen because it was not possible to install an external insulation. The wall heating was chosen because of its better comfort-parameters and also in order to compare the energy effects of the wall heating with the ones of a convector heating. The advantage of the houses is that they are very similar so that a good comparison between them is possible.

In two units, one with wall heating and one with convector heating, indoor and outdoor temperature and humidity at several points in the construction and the heat flow will be monitored.

- The energy consumption before and after is calculated, not measured because from before no data is available and at the time of writing this documentation the building was still under construction.

5.5 Measures planned and done

- Floors: 14–16 cm Polystyrol insulation, U-value 0.35–0.38 W/m²K
- Walls: In three buildings 3 cm Klimasan insulation plaster, U-value: 0.078 W/m²K; in the other buildings 5 cm Ytong Multipor, U-value: 0.045 W/m²K
- Roofs: 24 cm Mineral and fiber insulation material, U-value: 0.035 W/m²K
- Windows: Double-glazing insulation, U-value 1.26–1.99 W/m²K
- Doors: New Doors U-value 1.3–1.8 W/m²K
- Heating system: In building 3, 5 and 8 wall heating systems, in the rest of the buildings (1, 2, 4, 6 and 7) convector heating
- Energy supply: District heating, primary-energy factor 0.67
- Hot water: District heating, primary-energy factor 0.67
- Shading system: Inner shading system for most of the windows in the walls and outer shading system for the roof windows and some windows in the walls ; sun protection glazing

5.6 Costs & financing

1. Costs		**total costs (in €)**
Insulation of roof, etc.:		21,000
Insulation of soffit with Calcium Silicate:		4,600
Closing of slots in wall:		900
Doors and windows:		54,000
New cellar doors:		700
New cellar windows:		1,300
Solar shielding:		1,000
Wall insulation with 3 cm insulation plaster:		32,000
Wall heating system and other heating devices incl. pipes, etc.:		35,000
	sum 1	**Net 145,900** **Gross 173,621**

2. Financing	**internal rate of return, interest rate (in %)**	**funding sum (in €)**
Own money		3.5 Mio €
Bank credit		6.7 Mio €
Public funding		2.2 Mio €
Donations (BSR programme)		0.3 Mio €
sum 2		**12.7 Mio €**

3. Amortisation			
Heating cost before refurbishment	**energy use p. a. (in kWh)**	**cost per kWh (in €)**	**total cost p. a. (in €)**
Oil	202,401	0.085	Gross 17,224
Heating cost after refurbishment	**energy use p. a. (in kWh) (estimated)**	**cost per kWh (estimated)**	**total cost p. a. (estimated)**
Oil	–	0,22	–
Local district heating	25,104	0.06	Gross 1,543
Payback period for the refurbishment		**amortisation period (in years)**	**cost savings p. a. in €**
		13	Gross 13,180

Additional information:

- The Co₂olBricks project partner Hamburg Department for Heritage Preservation supported the house owners in financing the necessary calculations to determine the thickness of the internal insulation.
- The calculations of the building costs, heating costs before and after renovation are all referring only to building no 3. It is one with wall heating system. The financing costs are referring to the whole project of 8 buildings because for personal data protection it was not possible to get more detailed financing data. So the numbers given show avarage values which can not necessarily be directly applied to building no 3.

5.7 Conclusion and lessons learnt

From the conservators point of view

It was unexpectedly intricate to compare the two variants ‘wall heating’ and ‘convector heating’ because in the regular technical regulations the room air temperature is the only parameter regarding comfort-values. A mixture of comfort, hygiene and effectivity of the wall heating should be the parameters to be examined. Therefore it should be taken into consideration to complement the existing energy-efficiency calculation system with a method which allows to calculate wall heating systems.

An important lesson learnt is that the technology for long term measurements of temperature and humidity of walls, including the equipment as well as the technique to apply the gauges to the walls, is very complex. Only a few highly qualified and experienced institutes exist, which are able to ensure resilient measuring results.

In the planning process one of the major problems was to convince the local public building support bank to give their permission for the special loan for energy efficiency to be used for the wall heating system. This was due to the fact that in the regular calculation software wall heating and internal insulation were not implemented. Therefore an alternative calculation method, a hygrothermal simulation, had to be used. The costs for this alternative calculations were coverd by Co_2olBricks because they were so high, that a normal house owner would not have been able to cover them. Only by this hygrothermal simulation it was possible to determine the optimal material for the internal insulation and the optimal thickness of its layers in combination with the wall heating and the convector heating systems.

As an outlook for future projects the finding is that due to the low system-temperatures, which are necessary for wall heating systems, interesting options to install low temperature renewable heating-systems, such as heat pumps, geothermal energy or solar systems, come into sight. This is due to the fact that these renewable systems often provide the energy already at the right temperatures for the wall heating systems so that the losses by converting energy can possibly be reduced.

From the architects perspective

A big challenge was to get all technical energy consultants under one roof, e. g. the research institute for hygrothermal simulation, the expert for noise protection, the energy consultant, the technical facility planner. A very good factor was that this fact was known from the beginning on because back then it was already planned to install a wall heating system and an internal insulation. This meant that the complexity of the project was well known, as well as the fact that more consulting than usual would be necessary. Due to the complexity and the fact of 29 different owners it took one year to come to a balanced concept where everybody now has the feeling that a technically feasible solution has been found.

The house owners quickly recognized the advantages of a wall heating system and therefore it was no difficulty to find enough units to install it. The heating energy is produced by a combined central heat and power unit. The selection process for this unit was a long process during which many possibilities were assessed and eventually a gas fired combined heat production was selected. An already existing boiler room was reused.

For the internal insulation it is necessary that the outer wall is rain proof and it was a difficult process to select the right method. The problem was that it is not clearly definded, neither in the literature nor through the participating research institute, at what point rain proofnes is achieved. So a building physics office had to be commissioned to work out the appropriate solution. The chosen solution was to refurbish the joints.

Legal aspects

The climate protection plan of Hamburg and the German Energy Saving Directive (ENEV) require certain minimum energy efficiency standards. Although this listed building is exempt from the ENEV, the public authority issuing the building permission was difficult to convince of the concept.

Proposal for future projects

More investigation about possibilities to achieve a risk free outer wall construction from the point of building physics at the lowest possible effort are necessary. The thorough analysis should next time in any case include the investigation of the rain proofness of the wall because the rainproofness is a precondidtion for the internal insulation. In this respect the difficult planning process was worth every endeavour because now a solution has been found where the architect does not expect any problems anymore.

From the owners perspective

If there had not been the financial support to cover the extra costs of the wall heating systems, the house owners probably would not have chosen this system. On the other hand more owners would have liked to install the wall heating system but due to limited funding resources the total number of wall heating systems was limited. But now they are satisfied to have two systems so that they can compare them. They are also content that this way they can contribute to the preservation of a listed brick building.

Another problem was that within the buildings which contain several units the individual owners were not always of the same opinion and therefore the majority decided which system (wall heating or conventional convection heating) was to be installed in the house. By this procedure not everybody got the system he preferred. Many users were open to both systems, some even had already personal experiences with surface heating systems. But it has to be stated that all in all not very many field reports about wall heating systems were available to the users. Internal insulation and floor heating was easily understood by most of the users but the wall heating concept was more difficult to understand. So eventually the users had to trust the experts from the architects office, the resarach institute and the conservators.

› Here the windows account relatively for the biggest part of energy losses in the building. ‹

6. Pilot project 'Old School Building', Kohtla-Järve

/ JELENA DULNEWA, TARMO A. ELVISTO

EST

6.1 Project description

The brick school building, built in 1938/39 from Anton Lembit Soans, is a listed monument and property of the Town Government. The building consists of three floors in the main building and an added gym hall. Some parts of the building were reconstructed, but nevertheless it is still in a bad state and has to be refurbished fundamentally in future.

Address: Spordi 2, Kohtla-Järve, Estonia
Building type: school building
Architect: Anton-Lembit-Soans
Year of construction: 1938/1939
Owner: Kohtla-Järve Town Government
Used as: premises for the vocational training of unemployed, art studios, a hostel, gym for an aerobic club
Number of floors: main building 3 floors + basement, gym 1 floor + basement, tower 6 floors
Façade: bricks and plaster
Floor space: 3.594 m²
Heated area: 3.594 m²
Cost of refurbishment: 59,188 €

6.2 Initial situation



Heating system / production

Old: district heating with old radiators

Building services

Electricity: electric wearing is in bad condition

Water / waste water: in bad condition

Energy consumption

Before, measured: 405,42 MWh/a

After, calculated: na

After, measured: na

Energy saving: na

CO_2 saving: na

Refurbishment

Start: August 2013

End: November 2013

Architect: Scandec Ehitus OÜ

The building of the famous Estonian architect is representative for the school architecture of the period of the 30–40s of the 20th century. It is nowadays used as a gym for a gymnastic club, a hostel, and for art workshops. Some parts of the building have a tenant – a training centre for unemployed. It is planned to use the building in the future as a public "Oil Shale Mining and Processing Museum".

The Cultural Heritage number of the building is 13886 on the Regulation of the Minister of Culture No. 73 dated 13.11.1997, (RTL 1997, 214, 1130). The following expert´s report about the heritage value exists: "Special Terms for Refurbishment and Reconstruction of Heritage Buildings" by Andrey Ksenofontov, Tallinn, 2010 approved 04.05.2011 by Madis Tuuder, inspector of National Heritage Board of Estonia (approval nr. 15563). The Property owner has to follow the national regulations concerning the maintenance and refurbishment of the building.

The building is partly renovated, but still in poor condition in total. The façades have the most urgent need of repair and restoration. But also the terraces, the roof, windows and the external doors of the building have to be refurbished. Most of the problems inside the building are caused by leaks and high humidity. The bearing structure and the floors are deteriorating. The ornamentation, balconies, railings, cornices and columns on the façades are also deteriorating. In order to prevent further decay, the roof and the windows must be restored and renovated first.

6.3 Motivation to select the specific measures

Material
Façade: bricks, plaster
Roof: main building eternit plates; gym bearing metal girder with wooden trussing
Windows: a mixture of types; original with box-type windows
Shading system: no
Floor: concrete, wood
Ceiling: wooden beams, reinforced concrete
Inner Walls: solid brick wall and lath
Cellar: bricks and flagstone
Foundation: concrete

The gym is a separate part of the building where it is possible to work out energy efficiency measures valuable for the whole project. Here the windows account relatively for the biggest part of energy losses in the building. The original windows were box-type windows, but the original windows do not exist anymore. Almost all existing windows have been built after the 2nd WW, in their appearance and construction identical to the original ones. Some of the windows, mostly in the basement, are bricked up. So it was a big challenge to work out the best way for refurbishing the windows. For that reasons the windows were chosen to demonstrate the possible measures and their effects concerning the energy efficiency.

Furthermore there is a huge lack of knowledge in general in that sphere in Estonia and other Baltic Sea countries. This project has led to information that is very valuable for heritage protection and for sustainable energy measures in Estonia as well as for other European countries. There are many new innovative measures to achieve positive energy effects by refurbishing of old windows, e. g. special glazing, films for glazing, special technologies for third glazing and others. The idea was to use the valuable knowledge about energy films, third glazing and other methods from Germany and to combine it with knowledge and technics from Estonia.

The project was planned and implemented in the following steps:
- An energy audit for the gym including measurements about the existing situation and a concept for the improvement of the energy efficiency
- A concept for window restoration, including descriptions and calculations for different measures
- Practical restoration of windows, including energy efficiency-Instructions for making old windows more energy efficient

The calculation for the 4 steps is:
- 10,000 € for engineering
- 50,000 € for the practical works including new innovative materials and technics

6.4 Costs & financing

1. Costs		total costs (in €)
Energy audit for the former school building		1,190.00
Examination of the technical condition of the gym		1,536.00
The general concept/construction project for the gym		4,971.55
Restoration work for the windows in the gym		50,650.92
Building inspection		840.00
	sum 1	**59,188.47 €**

2. Financing	internal rate of return, interest rate (in %)	funding sum (in €)
Own money		8,878
Bank credit		na
Public funding		na
Donations (BSR programme)		50,310
	sum 2	**59,188 €**

6.5 History and historical value

Initially the research and planning of energy-efficient refurbishment measures as part of the Co_2olBricks project was intended to be done for a different historical building – the Kohtla-Järve Cultural Centre. However, this object received funding for its complete restoration from ERDF, totalling 1,800,000 €. Other options had been considered for the Co_2olBricks project and eventually a decision was made jointly with the Lead Partner to select the former school building, which is also listed as architectural heritage. The project budget included investment funding totalling 60,000 € to be used for implementation of certain refurbishment works which would result in a perceptible reduction of energy costs. Despite the fact that Estonian legislation does not require audits for protected historical buildings, an energy audit was implemented as part of the Co_2olBricks project. Consequently an analysis of the energy consumption and energy costs in this building was performed, the most problematic places were visualised through thermography, and suggestions for their elimination were provided in order to achieve maximum energy efficiency of the building during renovation. As the refurbishment of the whole monument building requires considerable investments, it was decided that only one part of it – the gym – had to be examined in detail. The gym is used by children and the indoor climate is very important for their training. The reduction of humidity in this part of the building is also very essential and important for the future restoration. In the course of the international Co_2olBricks project partner workshop various options regarding possible works in the framework of this project were considered. As a result the workshop participants expressed their general opinion that there is a need to focus the attention on replacing the windows in the gym. Other suggestions included the improvement of the heating and lighting situation in the gym. Further activities of the project group concentrated on implementing these decisions in adherence to the given project budget.

According to the results of the thermography performed by Viru Energiaaudiit NV OÜ, the greatest heat losses proceed through the shell of the building – external walls, windows, doors, intermediate floors and roof. The results of this energy audit were the basis for choosing energy saving measures to reduce the energy consumption of this building. The first of these measures was to improve the thermal resistance of the windows. The heat losses of a square meter of glass surface are from four to six times higher than the ones of a wall. This is especially important for the large window surfaces. The present windows have been preserved from the time of the building's construction or mostly from the time when it was renovated after the 2nd WW, during which the building was quite seriously damaged.

One of the advantages of old wooden windows is their authenticity and singularity. From the heat resistance point of view the main advantage of old windows, compared to the new ones, is a wider gap between the interior and exterior window frames (it is the air that holds the heat, not the glass) and the more massive window cases. The windows of the gym are considered historically valuable, but they do not meet the actual energy saving standards. At the moment the thermal conductivity of the gym windows is 2.1 W/m^2K (for the whole building, according to the data from the energy audit, the average thermal conductivity of the windows is about 3.0 W/m^2K). It was suggested to lower this value to 1.1 W/m^2K. For the Estonian climate it is not advised to reduce the U-value to figures lower than 1.1 W/m^2K as this can cause condensate on the external surface of a double-glazed window. The heat thermal resistance of windows can also be improved by the use of curtains.

By increasing the thermal resistance of windows energy saving of 11 MWh/a can be reached, which leads to a payback period of 89 years. In the restoration project every window was examined and a table of damages was compiled for every window separately. This way of examination provides accurate data about the condition of the windows and allows to prepare a more accurate calculation of the refurbishment expenses.

According to this research, presented as part of the restoration project, the condition of the windows in the gym is mostly unsatisfactory. In order to renovate them and to improve their thermal resistance it was suggested to preserve only the external window frames and cases (but the glass panes should be replaced) and to replace interior windows with contemporary wooden double-glazed windows with selective glass. This is the most popular type of glass used for improving the thermal resistance of windows in Estonia. Selective glass blocks the heat radiating through the window from objects inside of the building, lets as much daylight as possible pass and prevents transmission of as much solar heat as possible. Use of selective glass in a double-glazed window reduces the loss of heat by up to 30 %. Selective glass is usually installed on the internal side of a double-glazed window. Also the space between the glasses should be filled with argon, which provides additional thermal resistance compared with air-filled double-glazing. As for the external window frames the decayed parts should be replaced and new fragments similar to the existing ones should be produced. New metal fittings should be installed both on the external and internal window frames. To avoid the appearance of air humidity on the internal side of the external window, the air circulation between the glass surfaces should be improved. In the restoration project, it was advised not to install contemporary sealers on the external window in order to provide the essential air movement.

6.6 Description of process

- An energy audit for the whole school building was performed on 13.02.2012 by Viru Energiaudit Company
- On 23.05.2012 the $Co_2olBricks$ project partner workshop was conducted in the building, where some specific steps for the future renovation were worked out and recommended to the property owner by international specialists and experts
- An examination of the technical condition of the gym was performed on 22.05.2012 by Zoroaster Company. The results of the expert examination were approved on 21.09.2012 by Kalle Merilai, senior inspector of National Heritage Board of Estonia (approval nr. 18880)
- The general concept/construction project for the gym was designed by the Zoroaster Company and presented to the property owner on 25.06.2013; the concept was approved on 16.07.2013 by Kalle Merilai, senior inspector of National Heritage Board of Estonia (approval nr. 20798)
- The permission for the construction works in the school building, Spordi 2, Kohtla-Järve, was issued on 06.08.2013 by the Kohtla-Järve Town Government order nr. 599
- The permission for the restoration work execution nr. 10810 was issued on 02.09.2013 by Kalle Merilai, senior inspector of National Heritage Board of Estonia
- In accordance with the Contract nr 30082013/ LV nr.17–1.1.1/24 the restoration were started on 30.08.2013 and are due to continue till 31.10.2013, the Contractor is Scandec Ehitus OÜ

6.7 Conclusion and lessons learnt

As part of the $Co_2olBricks$ project workgroup meetings, workshops and information seminars were organised to join forces of property owners, representatives of organisations responsible for the preservation of architectural heritages, architects, construction specialists, energy saving experts and representatives of property management organisations. By using a specific building as an example various problems and their possible solutions were discussed. This became possible thanks to the co-operation and exchange of experience between profile experts. The results of the discussions served as foundation for the compilation of the expression of requirements for the project for the renovation of the gym. It is worth noting that this method of work is especially important in a situation where financial resources are limited and works need to be implemented in stages. With mutual cooperation it is possible to define most effectively the top-priority tasks that will not only work for the preservation of the building but will also lead to a decrease in heat losses and therefore also to a decrease of energy costs.

The implementation of the window renovation in the pilot project serves as a descriptive case for property owners and construction experts who discard older windows during reconstruction and do not consider it necessary to analyse their condition. This quite often has the results that the architectural and aesthetic appearance of the building is spoilt and that the costs of the construction works increase. It would be far more rational to use the budget to implement energy saving measures for windows.

An essential element of the continuous work in WP4 is the dissemination of information about the partner's work results, incl. pilot projects, the promotion of the considerations for historical buildings and of the practicability of addressing the issues of energy efficiency and energy saving. Providing stakeholders with information on state-of-the-art energy efficient technology and equipment, conducting workshops, and offering expert training are the tasks that should remain in the focus even after the conclusion of the $Co_2olBricks$ project.

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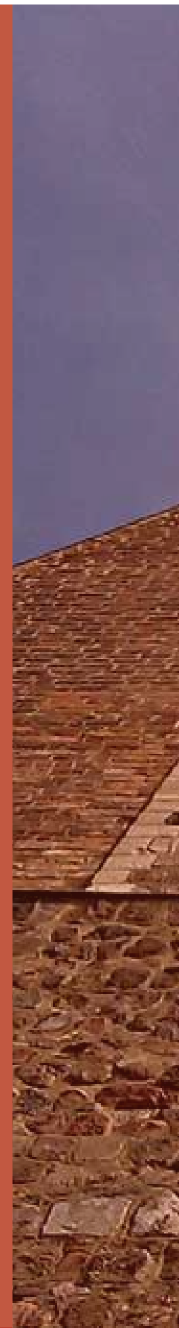

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