International Energy Agency

Shining Examples of Cost-Effective Energy and Carbon Emissions Optimization in Building Renovation (Annex 56)

Energy in Buildings and Communities Programme

May 2014

EBC is a programme of the International Energy Agency (IEA)

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Preface

The International Energy Agency

The International Energy Agency (IEA) was established in 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an international energy programme. A basic aim of the IEA is to foster international co-operation among the 28 IEA participating countries and to increase energy security through energy research, development and demonstration in the fields of technologies for energy efficiency and renewable energy sources.

The IEA Energy in Buildings and Communities Programme

The IEA co-ordinates research and development in a number of areas related to energy. The mission of the Energy in Buildings and Communities (EBC) Programme is to develop and facilitate the integration of technologies and processes for energy efficiency and conservation into healthy, low emission, and sustainable buildings and communities, through innovation and research. (Until March 2013, the IEA-EBC Programme was known as the Energy in Buildings and Community Systems Programme, ECBCS.)

The research and development strategies of the IEA-EBC Programme are derived from research drivers, national programmes within IEA countries, and the IEA Future Buildings Forum Think Tank Workshops. The research and development (R&D) strategies of IEA-EBC aim to exploit technological opportunities to save energy in the buildings sector, and to remove technical obstacles to market penetration of new energy efficient technologies. The R&D strategies apply to residential, commercial, office buildings and community systems, and will impact the building industry in five focus areas for R&D activities:

- Integrated planning and building design
- Building energy systems
- Building envelope
- Community scale methods
- Real building energy use

The Executive Committee

Overall control of the IEA-EBC Programme is maintained by an Executive Committee, which not only monitors existing projects, but also identifies new strategic areas in which collaborative efforts may be beneficial. As the Programme is based on a contract with the IEA, the projects are legally established as Annexes to the IEA-EBC Implementing Agreement. At the present time, the following projects have been initiated by the IEA-EBC Executive Committee, with completed projects identified by (*) (see following table):

Annex 1: Load Energy Determination of Buildings (*)
Annex 2: Ekistics and Advanced Community Energy Systems (*)
Annex 3: Energy Conservation in Residential Buildings (*)
Annex 4: Glasgow Commercial Building Monitoring (*)
Annex 5: Air Infiltration and Ventilation Centre
Annex 6: Energy Systems and Design of Communities (*)
Annex 7: Local Government Energy Planning (*)
Annex 8: Inhabitants Behaviour with Regard to Ventilation (*)
Annex 9: Minimum Ventilation Rates (*)
Annex 10: Building HVAC System Simulation (*)
Annex 11: Energy Auditing (*)
Annex 12: Windows and Fenestration (*)
Annex 13: Energy Management in Hospitals (*)
Annex 14: Condensation and Energy (*)
Annex 15: Energy Efficiency in Schools (*)
Annex 16: BEMS 1- User Interfaces and System Integration (*)
Annex 17: BEMS 2- Evaluation and Emulation Techniques (*)
Annex 18: Demand Controlled Ventilation Systems (*)
Annex 19: Low Slope Roof Systems (*)
Annex 20: Air Flow Patterns within Buildings (*)
Annex 21: Thermal Modelling (*)
Annex 22: Energy Efficient Communities (*)
Annex 23: Multi Zone Air Flow Modelling (COMIS) (*)
Annex 24: Heat, Air and Moisture Transfer in Envelopes (*)
Annex 25: Real time HVAC Simulation (*)
Annex 26: Energy Efficient Ventilation of Large Enclosures (*)
Annex 27: Evaluation and Demonstration of Domestic Ventilation Systems (*)
Annex 28: Low Energy Cooling Systems (*)
Annex 29: Daylight in Buildings (*)
Annex 30: Bringing Simulation to Application (*)
Annex 31: Energy-Related Environmental Impact of Buildings (*)
Annex 32: Integral Building Envelope Performance Assessment (*)
Annex 33: Advanced Local Energy Planning (*)
Annex 34: Computer-Aided Evaluation of HVAC System Performance (*)
Annex 35: Design of Energy Efficient Hybrid Ventilation (HYBVENT) (*)
Annex 36: Retrofitting of Educational Buildings (*)
Annex 37: Low Exergy Systems for Heating and Cooling of Buildings (LowEx) (*)
Annex 38: Solar Sustainable Housing (*)
Annex 39: High Performance Insulation Systems (*)
Annex 40: Building Commissioning to Improve Energy Performance (*)
Annex 41: Whole Building Heat, Air and Moisture Response (MOIST-ENG) (*)
Annex 42: The Simulation of Building-Integrated Fuel Cell and Other Cogeneration Systems (FC+COGEN-SIM) (*)
Annex 43: Testing and Validation of Building Energy Simulation Tools (*)
Annex 44: Integrating Environmentally Responsive Elements in Buildings (*)
Annex 45: Energy Efficient Electric Lighting for Buildings (*)
Annex 46: Holistic Assessment Tool-kit on Energy Efficient Retrofit Measures for Government Buildings (EnERGo) (*)
Annex 47: Cost-Effective Commissioning for Existing and Low Energy Buildings (*)
Annex 48: Heat Pumping and Reversible Air Conditioning (*)
Annex 49: Low Exergy Systems for High Performance Buildings and Communities (*)
Annex 50: Prefabricated Systems for Low Energy Renovation of Residential Buildings (*)
Annex 51: Energy Efficient Communities (*)
Annex 52: Towards Net Zero Energy Solar Buildings

Annex 53: Total Energy Use in Buildings: Analysis & Evaluation Methods (*)
Annex 54: Integration of Micro-Generation & Related Energy Technologies in Buildings
Annex 55: Reliability of Energy Efficient Building Retrofitting - Probability Assessment of Performance & Cost (RAP-RETRO)
Annex 56: Cost Effective Energy & CO2 Emissions Optimization in Building Renovation
Annex 57: Evaluation of Embodied Energy & CO2 Emissions for Building Construction
Annex 58: Reliable Building Energy Performance Characterisation Based on Full Scale Dynamic Measurements
Annex 59: High Temperature Cooling & Low Temperature Heating in Buildings
Annex 60: New Generation Computational Tools for Building & Community Energy Systems
Annex 61: Business and Technical Concepts for Deep Energy Retrofit of Public Buildings
Annex 62: Ventilative Cooling
Annex 63: Implementation of Energy Strategies in Communities
Annex 64: LowEx Communities - Optimised Performance of Energy Supply Systems with Energy Principles
Annex 65: Long-Term Performance of Super-Insulation in Building Components and Systems
Annex 66: Definition and Simulation of Occupant Behaviour in Buildings

Working Group - Energy Efficiency in Educational Buildings(*)
Working Group - Indicators of Energy Efficiency in Cold Climate Buildings(*)
Working Group - Annex 36 Extension: The Energy Concept Adviser(*)

Management Summary

This brochure is a selection of successful realised demonstration projects within Annex 56 partner countries that highlights successful solutions and provides general findings, similarities and differences emerging out of the demonstration projects selected in the participating countries.

The specific mission of the case study activity of the Annex 56 project is to provide significant feedback from practice (realised, ongoing or intended renovation projects) on a scientific basis.

Within Annex 56, the gathering of case studies is one of the activities undertaken to reach the overall project objectives, because it is a recognized fact that the process of decision-making has to be strongly supported by success stories from real life and experiences and lessons learned from practice.

The “Shining Examples” are gathered mainly for motivation and stimulation purposes, highlighting the advantages of aiming at far reaching energy and carbon emissions reductions, being still cost effective. The focus is to highlight advantages and innovative (but feasible) solutions and strategies.

In this report 9 shining examples are presented in a standard format:

- Austria: Kapfenberg
- Denmark: Traneparken, Hvalsø & Skodsborgvej, Virum
- Netherlands: Wijk van Morgen, Kerkrade
- Portugal: Lugar de Pontes, Melgaço & Rainha Dona Leonor Neighbourhood, Porto
- Sweden: Brogården, Alingsås & Backa röd, Gothenburg
- Switzerland: Les Charpentiers, Morges

A cross-section analysis of these shining examples has also been carried out to identify similarities, differences and general findings. The results of this analysis are presented in 5 sections covering: barriers/solutions, anyway measures, rational use of energy/renewable energy supply (RUE/RES) balance of measures, co-benefits and country/climate specific measures.

The gathering of shining examples continues through the entire lifetime of Annex 56 and all examples will be presented in a final document at the end of the project.

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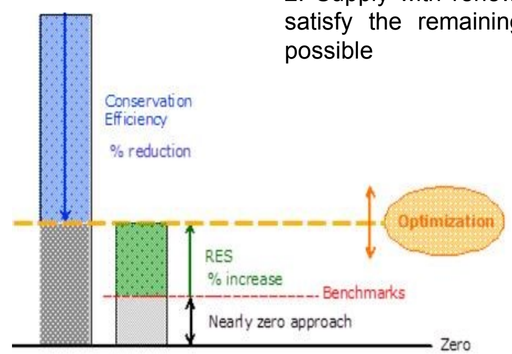
Introduction

Climate changes are evident all over the planet and it is no longer possible to ignore its relationship with the carbon emissions, deeply related to energy production and use. To tackle this problem different measures are being taken worldwide to promote energy efficiency and expand the use of renewable energy sources in all areas and particularly in the building sector, one of the most relevant energy consumers.

Several standards regarding energy consumption have emerged in the last decade, defining increasing requirements, and culminating with the recent emergence of the “nearly-zero energy” buildings concept. However, these standards are mainly focused on new buildings ignoring, most of the time, the existing ones that represent the least efficient, the largest consumers and the largest share of the building stock. These standards do not respond effectively to the numerous technical, functional and economic constraints of this kind of buildings resulting, many times, in very expensive measures and complex procedures, hardly accepted by owners or promoters.

Having in mind the overall objective of slowing down climate change, measures for the use of renewable energy can be as effective as energy conservation and efficiency measures and sometimes be obtained in a more cost effective way. *In existing buildings, the most cost-effective renovation solution is often a combination of energy efficiency measures and measures for the use of renewable energy.* Hence, it is relevant to understand how far it is possible to go with energy conservation and efficiency measures (initially often less expensive measures) and from which point the use of renewables become more economical considering the local context.

Two step approach:
1. Reduction of energy demand and carbon emissions by energy conservation and efficiency measures
2. Supply with renewable energy and on-site RES to satisfy the remaining energy demand as much as possible



Optimized building renovation concept (Geier S., Ott W.)

In this context, the International Energy Agency established an Implementing Agreement within the Energy in Buildings and Communities Program to undertake research and provide an international focus on Cost Effective Energy and Carbon Emissions Optimization in Building Renovation (EBC Annex 56). This is an ongoing project (2010-2015) that aims at developing a new methodology to enable cost effective renovation of existing buildings while optimizing energy consumption and carbon emissions reduction. This project is mainly focused on residential buildings, as these account for 75% of the total stock in Europe and were, in 2009, responsible for 68% of the total final energy use in buildings, comprising a less heterogeneous sector compared to the non-residential sector, which suggests a higher potential for improvement.

To achieve these goals, to have a bigger impact and to shorten the path to the application of the project results, it is important to take advantage of good examples and good practices already implemented as well as of existing and emerging efficient technologies with potential to be successfully applied.

This brochure is a selection of successful realised demonstration projects within Annex 56 partner countries that highlights successful solutions and provides general findings, similarities and differences emerging out of the demonstration projects selected in the participating countries.

The Operating Agent

Prof. Manuela Almeida

Scope of the Brochure

Within Annex 56, the gathering of case studies is one of the activities undertaken to reach the overall project objectives because it is a recognized fact that the process of decision-making has to be strongly supported by success stories from real life and experiences and lessons learned from practice.

The specific mission of the case study activity of the Annex 56 project is to provide significant feedback from practice (realised, ongoing or intended renovation projects) on a scientific basis. The main objectives of this work are:

- To understand barriers and constraints for high performance renovations by a thorough analysis of the case studies and feedback from practice in order to identify and show measures to overcome them;
- To align the methodology under development in Annex 56 with practical experiences;
- To support decision-makers and experts with profound, scientific based information (as result of thoroughly analysed case-studies) for their future decisions;
- To show successful renovation projects in order to motivate decision-makers and stimulate the market.

The Case Studies within Annex 56 will be studied at two different levels. Level 1 – the “Shining Examples” and level 2 – the “Detailed Case Studies”. It is expected that every country provides at least one demonstration project (preferentially more) in order to cover a broad variety of different climate and framework conditions. Within level 1, a selection of “Shining Examples” to encourage decision makers to promote efficient and cost effective renovations will be provided. In a second phase, within “Detailed Case Studies”, a deeper analysis will be performed in order to evaluate the impact and relevance of different renovation measures and strategies within the project objectives and also validating the methodology under development in Annex 56. The results from the level 2 analysis are on-going and will be reported separately.

This brochure presents the Shining Examples collected so far in a fixed format showing for each demonstration project pictures and easily comprehensible graphics, highlighting the added-value of the renovation process. The brochure presents 9 Shining Examples from 6 countries. The gathering of shining examples continues through the entire lifetime of Annex 56 and all examples will be presented in a final document at the end of the project. At the end of the project is expected to have about 20 Shining Examples from 9 countries.

The “Shining Examples” are gathered mainly for motivation and stimulation purposes, highlighting the advantages of the energy and carbon emissions cost optimized renovation. The focus is to highlight advantages and innovative (and feasible) solutions and strategies. A cross-section analysis of the projects has also been carried out to identify similarities, differences and general findings. The results of this analysis are presented in 5 sections covering: barriers/solutions, anyway measures, rational use of energy/renewable energy supply (RUE/RES) balance of measures, co-benefits and country/climate specific measures.

Case Studies

Country	Site	Building type	Barriers / solutions	Anyway measures	Which measures	Co - benefits	Country / climate specific measures	Picture
AUSTRIA	Kapfenberg	Multi family	√	√	√	√	√	
DENMARK	Skodsborgvej, Virum	Single family	-	√	√	√	√	
DENMARK	Traneparken, Hvalsø	Multi family	√	√	√	√	√	
NETHERLANDS	Wijk van Morgen, Kerkrade	Single family	-	√	-	√	√	
PORTUGAL	Lugar de Pontes, Melgaço	Single family	√	√	√	√	√	
PORTUGAL	Neighborhood RDL, Porto	Multi family	√	√	√	√	√	
SWEDEN	Backa röd, Gothenburg	Multi family	-	√	√	√	√	
SWEDEN	Brogården, Alingsås	Multi family	√	√	√	√	√	
SWITZERLAND	Les Charpentiers, Morges	Multi family	√	√	√	√	√	

Building Analysis

Barriers / Solutions

The implementation of energy renovation projects in the building sector is not just a technical and/or economical matter. It involves the users/inhabitants/owners of the buildings, who, in some cases, have to leave the buildings for a shorter or longer period of time. Additionally, those who pay for the energy renovation are not always those who benefit from it. Therefore, energy renovation projects often run into barriers that may hold up the project. It is then a must that owners, technical consultants and policy makers find solutions to overcome these barriers. In a pre-study on barriers and solutions carried out in the context of this work, four different categories of barriers were identified:

- Information issues;
- Technical issues;
- Ownership issues;
- Economic issues.

The information issues can be either confusing information, i.e. different opinions expressed by different professionals, or incomplete information. It can also be lack of clear requirements, lack of inspiration or lack of knowledge about possibilities, potential benefits and added values.

The technical issues are mainly related to lack of well proven systems and lack of complete solutions consisting of packages of technologies.

The ownership issues generally have to do with who has to pay for the investment in energy renovations and who saves the money – not always the same person(s).

The economic issues can be as simple as too high investments needed, which often are also coupled with lack of incentives. Additionally, there may be uncertainty as to how much money can be saved from the energy renovation (sometimes just the comfort is improved) and finally, lack of economic understanding or knowledge.

Barriers and solutions observed in the 9 shining examples

The barriers met in the energy renovation process of the 9 shining examples in this brochure and the solutions to overcome them have been identified in the descriptions of each case-study (presented later in this document) and compiled in the following table.

From this table it appears that the barriers met were sometimes a combination of different kinds of barriers including information, economic and ownership/user issues. Tenants in rented apartments are often in focus as critical elements in the renewal process as for example in the Swiss case, where it was important to keep the largest possible number of tenants in their apartments during the renovation. In Denmark, tenants came into play in a different way as the democratic requirements in the Danish housing rent laws demand that tenants vote for the energy renovation before it can be initiated.

Country	Designation	Barriers	Solutions
Austria	Kapfenberg	— The financing of the renovation was a barrier because, due to governmental regulations, it was not possible to excessively increase the rental prices for the apartments; — Additionally, the renovation works inside the building, such as the change of the layout, made a resettlement of the residents necessary.	— Other funding and financing solutions were necessary to realise the renovation; — Due to the fact that there were no apartments available in Kapfenberg at the time of the renovation, this process could only be put into practice in two different construction phases in order to guarantee the residents an apartment during the renovation period.
Denmark	Traneparken	— There were practical administrative barriers to convince the tenants that is was a good idea to carry out the energy renovation.	— These barriers were overcome without too much trouble by thoroughly informing the tenants about potential benefits and added values of the project.
Portugal	Pontes Country House	— Obtaining the building permit from the municipality and from national tourism entities is still a time consuming process that causes delays and doubts for the business plan; — With respect to the investment costs, the building owners not always understood the unconventional nature of the renovation project and, therefore, expected only conventional costs, both for the renovation works and for the consultants.	— In this process, this barrier was not overcome; — This barrier was overcome giving substantial information to the owners about potential benefits and added values of the project.
Portugal	Bairro Rainha Dona Leonor	— The lack of financing to carry out the works at once was a big barrier; — Strong discussion whether the best solution was to renovate or to demolish and transfer tenants to other buildings; — The need to have the buildings vacant to carry out the renovation works.	— The works have been divided in several phases over several years; — The decision has been of political nature. Benefits from energy related measures were not considered and could have helped the decision process. — Vacant dwellings from other neighbourhoods have been used to temporarily house the tenants.

Country	Designation	Barriers	Solutions
Switzerland	Les Charpentiers	— The challenge was to perform the renovation keeping the largest possible number of tenants.	— Some tenants were moved several times.
Sweden	Brogården	— A delay was caused by poor project management. The preservation of the area and accessibility questions took much time in the planning process; — The energy issues were first almost neglected.	— The project management was replaced; — A person was put in charge of the energy issues.

The barrier observed in one of the Swedish projects was related to poor project management in the early phase, which obviously underlines the importance of a good plan from the start when a new renovation project is initiated.

In Portugal, the financing was a barrier in both cases and also in both, the lack of knowledge by some stakeholders and different opinions among involved partners, were issues necessary to deal with.

In all cases, the solutions found to overcome the barriers met were quite straightforward and can be summarized in one word: "perseverance". Many of these projects could not have been implemented if a single person or team had not taken ownership of the project and had fought for their completion.

Conclusions

The overall conclusion from the analysis of the 9 shining examples is that for 3 of these there were apparently no barriers worth mentioning. For 3 of them, the barriers were mainly of administrative matter – for example delay caused by poor project leadership. For 2 of the cases, the economical/ financing issues created barriers causing problems and delays. This conclusion differs somehow from the result of a questionnaire carried out earlier among the participants in this project where the lack of information and lack of economic incentives were mentioned as barriers for, respectively, all of the case-studies and in 9 of the 10 countries that answered the questionnaire. This may be explained by the fact that these are general barriers, which block the carrying through of energy renovation projects, whereas in the 9 shining examples presented here they were obviously overcome.

The shining examples documented so far may be characterised as forerunners and therefore not typical energy renovation projects, which may explain the fact that only few of the general barriers identified in the questionnaire are represented.

Anyway measures

The expression “anyway measures” was chosen to highlight the inevitability of the costs associated to maintaining, extending or replacing materials, equipment and systems to keep the building fully functional, or to make it contemporary with impending mandatory regulations.

The definition of a “Cost Effective Energy and Carbon Emissions Optimization in Building Renovation” calculation requires a reference scenario. Having in mind that the optimization costs include all expenses regarding the optimization and related procedures (soft costs), it is fair to assume “anyway measures” costs deducted from this total investment, as they would occur anyway without optimization. In fact, these “anyway measures” can be triggers for intervention, as demonstrated later.

For the purpose of this publication, “anyway measures” will be defined as the “*set of actions, products and services necessary to guarantee the regular, safe and legal functions and aesthetics of an existing building*”.

The scope of the “anyway measures” tag includes all the costs that would naturally occur during the expected lifetime of the building and without which failure would occur. Well performed “anyway measures” increase or maintain the existing building value, and the same can be achieved by well performed optimization interventions.

The “anyway measures” considered in this publication include all the costs that the proposed optimization measures are able to substitute or defer in the existing building. The optimization of external walls, applied in all “shining examples” of this brochure, is helpful to explain:

a. Existing external walls require “anyway measures” that range from regular condition verifications to periodic paintings or substitution due to wear and tear. The “anyway measures” costs account for scaffolding or other lifting methods to execute the work, workmanship, materials and soft costs. In the end the aesthetics is improved or maintained, and the value of the building increases, or at least does not decrease.
b. An optimization measure using external insulation will need the same scaffolding or other lifting methods to execute the work, some of the workmanship and a few similar materials. The optimization measure costs can then be calculated accounting the expenses directly related to the optimization measure, subtracted by the values that would happen in the “anyway measures” described in a).

A brief analysis of the examples in this publication is provided to illustrate what was considered as “anyway measures”:

Optimization measures with deductible "anyway measures"	**Deductible "anyway measures"**	**Shining example**	**Comments**
Exterior insulation	– Exterior painting or rendering and scaffolding can be deducted	All "shining examples"	– Materials were ending their useful life expectancy, so the costs of fixing or replacing would happen soon
New radiator system with thermostat valves; District heating connection; Condensing gas boilers; Other new (more efficient) equipment	– Existing radiators and systems would have to be maintained or replaced anyway – The current price of a normal boiler, that would replace "anyway" the existing old one is deductible	Backa röd Brogården Kapfenberg Skodsborgvej	– Solutions that would probably happen anyway, even if no optimization was performed – District heating connections are an "anyway measure" where DHS are available – Replacing existent gas boilers in the end of their lifetime expectancy has a cost that can be deduced from the new more efficient equipment
Low energy fixed lighting	– Low energy lighting evolution, lowering cost and current regulations make it mandatory or unavoidable	Les Charpentiers Wijk van Morgen Backa röd Brogården Traneparken Pontes Country House	– As incandescent lights are being taken off the market, lighting will be an efficient "anyway measure" when replacement occurs. In Traneparken, Denmark, such options were already in place before intervention – Lighting fixtures introduced by users can´t be controlled
Gas cogeneration	– The radiators of the system could be deducted as they would be necessary anyway, or would replace existing old ones	Les Charpentiers	– The gas co-generation equipment is relatively new and still expensive. The investment in this equipment could be deduced by the price of locally prevalent heating solutions for each apartment (local standard). In scale, this solution can be more economic

Optimization measure with deductible "anyway measures"	Deductible "anyway measures"	Shining example	Comments
Accessibility (barriers reduction to widen the range of building users)	— As accessibilities are mandatory in many regulations, the installation of lifts or other accessibility improvements would have to happen anyway to keep the buildings legal.	Les Charpentiers Brogården Kapfenberg	— Lifts are very expensive and energy consuming equipment, but progressively assumed as necessary to guarantee the usability of the building by people of all ages and physical conditions; — Architectural solutions for accessibilities are also "anyway measures".
Heat-recovery ventilation and ducting;	— Mechanical ventilation and ducting replacement (if already existing); — In one situation the existing ducts and systems had to be replaced due to identified mould problems.	Traneparken	— Most of the times existing ducts for ventilation cannot be reused with new heat-recovery ventilation systems; — Optimization will not reduce the need for maintenance.
Measures without relevant optimization impact, although deductible (performed "anyway" during renovations)	— Structural strengthening; — Additional balconies; — Additional levels; — New kitchens and bathrooms; — Water and electrical networks.	Most of the "shining examples	— Costs related with water and electricity networks, kitchens and bathrooms, amongst other, only have indirect contribution to optimization. They would occur even if the energy optimization was not chosen, as they were ending their useful life expectancy; — Additions like balconies and new levels construction cannot be deduced as anyway measures, as they would not happen "anyway": they are" added value" that can make the optimization more attractive, or improve financial return;

Some of the “anyway measures” deductible costs need a context: the connection to district heating supply in the Kapfenberg example (Austria) would be beneficial to the society and to the users due to their efficiency. It would happen anyway, even if no optimization was performed.
But what all the examples show is that the need for renovation or maintenance, the need for the “anyway measures”, created most of the opportunities for renovation.

“Anyway measures” as triggers for optimization opportunities
This paragraph discusses the impact of context on the value and on the type of “anyway measures”. Building materials, equipment and systems are affected by normal ageing, by adverse conditions or by simple misuse.
To avoid degraded buildings, a set of maintenance operations are required that range from the response to slow decline - chronic occurrences - to the emergency resolution of failures - acute occurrences. Besides these, cultural and social expectations also play a role on the users´ decision to change, with potential impacts on the energy consumption, that will be briefly analysed in the subsection “Users expectations and compromise”. As disruptions to an existing status, these are opportunities towards wiser energy consumption.

Chronic occurrences
It is normally assumed that regular maintenance can extend the useful life of materials and, thus, the durability of buildings, but nevertheless unanticipated, rupture can occur, requiring fast-paced interventions to control further damage (see “Acute occurrences” bellow). In fact, the predictability of this natural decay can be used to adequately plan and anticipate interventions, and this publication is an effort to demonstrate the importance of optimization.
In programmed change situations it would be fair to assume that “anyway measures” can consider recent solutions that represent the local trends: if a district heating system is available, it is natural to consider that a system renovation would use the network solution.

Acute occurrences
In rupture related situations, “anyway measures” consist frequently in exchanging the existing system by an equivalent one, that will be more efficient due to the normal evolution of equipment, regulations and certification.
Imagining a gas based water heater failure, its probable replacement would raise efficiency values from about 65% to new standards of at least 80%. Nevertheless, “anyway measures” would rarely include a gas condensing boiler due to the extra space, cost and works; and an air to water heat pump would hardly be recommended by the gas technician.

The surprise of the acute occurrences does not leave much space for optimization measures unless a significant effort is made within installer’s practices. Nevertheless it is fair to assume that a related optimization measure can deduct the 80% efficiency gas water heater as the “anyway renovation” cost, the reference value to be deducted from optimization cost.

Users expectations and compromise
The relation between the best solution and the users’ choice is not linear, as most of the decisions are influenced by factors as status, availability or simple preference.

To simplify the evaluation, non-energy related “anyway measures” are only accounted if there is the need to deduce them from bulk final prices of investment. For instance, the introduction of efficient kitchen equipment is assumed to occur anyway, independently of optimization efforts, but this assumption is only valid while home appliances and personal energy uses are not accounted in buildings’ total energy consumption.

Which measures (RUE/RES balance)

When tackling energy consumption reduction in existing building renovation, two major approaches describe most of the options: those that reduce energy consumption, associated to a Rational Use of Energy (RUE), and those related to supplying the existing needs with Renewable Energy Sources (RES).

Many of the Rational Use of Energy (RUE) measures are currently less expensive while including the advantage of reducing the energy that has to be supplied by Renewable Energy Sources (RES), although further evolution in the existing or innovative technologies may alter this cost relation.

This brochure illustrates several examples where energy consumption reductions (RUE) were achieved by improving the performance of the building envelope and recovering heat from the ventilation losses, and others where significant use of solar panels or renewable-based district heating (RES) was used to complement the remainder needs. What both show is that each combination is a direct result from the existing context, the available solutions and sources, and significant integration efforts. Depending on the climate severity, period/quality of construction and many other factors (see topic Barriers) the buildings behave differently, create different baselines and require different intervention strategies.

Many of the RUE measures included the renovation of the boundaries with poor thermal performance (roofs, ceilings, walls, windows and floors with insufficient or no insulation), with particular focus on those in need of renovation due to wear and tear (see topic “Anyway measures”). The improvement of energy conservation noticed in roofs ranged from 30% to 95%, while in the walls it ranged from 60% to 90%. It is important to notice that in walls the U-values after renovation vary from 0.45 $W/m^{2}{}^{o}C$ in warmer climates to 0.11 $W/m^{2}{}^{o}C$ in more severe ones. In roofs, the variation ranged from 0.09 $W/m^{2}{}^{o}C$ to 0.64 $W/m^{2}{}^{o}C$, in the same situations.

In the particular case of windows, the improvements ranged from 15% to 75%, where countries and specific locations with higher demands for heating demonstrate the use of a wider range of high performance windows (triple glazing is rather common).

In most of the examples, the Rational Use of Energy (RUE) measures were taken as a first step to reduce the energy demand while improving the occupants’ comfort (see topic “Co-Benefits”), while reducing the amount needed from RES production.

The Renewable Energy Sources approach was implemented in most of the buildings in this brochure either by connecting to existing district heating structures fuelled by biomass or garbage combustion, or using biomass based heating systems. Many also included solar thermal panels for domestic hot water and/or heating, or solar photovoltaic (PV) panels for consumption or connection to the grid.

Kapfenberg, AT	Solar Thermal	40 MWh
	Photovoltaic	80 MWh
Skodsborgvei, DK	Solar Thermal	~ 5 sqm
Traneparken, DK	Photovoltaic	38 MWh
Melgaço, PT	Solar Thermal	4 MWh
	Heat Pump	x
Porto, PT	Solar Thermal	50 MWh
	Heat Pump	x
Backa röd, SE	RES via DH	x
Brogården, SE	RES via DH	x

Summary table for RES installed

		U-value W/m².ºC		
		before	after	improved by
Kapfenberg, AT	wall	0.87	0.17	80%
	roof	0.74	0.10	86%
	window	2.50	0.90	64%
Skodsborgvej DK	wall	1.65	0.29	82%
	roof	0.90	0.11	88%
	window	2.80	1.40	50%
Traneparken, DK	wall	0.66	0.15	77%
	roof	0.20	0.09	55%
	window	2.40	0.80	67%
Melgaço PT	wall	1.82	0.45	75%
	roof	4.55	0.23	95%
	window	4.60	2.05	55%
Porto PT	wall	1.38	0.45	67%
	roof	2.62	0.64	76%
	window	3.40	2.90	15%
Backa röd SE	wall	0.31	0.12	61%
	roof	0.14	0.10	29%
	window	2.40	0.90	63%
Brogården SE	wall	0.30	0.11	63%
	roof	0.22	0.13	41%
	window	2.00	0.85	58%
Morges CH	wall	1.20	0.11	91%
	roof	1.28	0.13	90%
	window	2.90	0.70	76%

Summary table for building envelope improvement

Preliminary Conclusions

This brochure reflects some renovation examples that are useful as depictions of built realities that, in a way or another, approach the topics under analysis in the scope of Annex 56.

This small illustration of “Shinning Examples” demonstrates that a “one size fits all” approach is unviable in the diversity of contexts where a “Cost Effective Energy and Carbon Emissions Optimization in Building Renovation” is needed. Case by case these examples show that the implemented RUE / RES measures were a consequence of local opportunities and constraints, ownership and local laws, and not only a design option.

The multidisciplinary design approach of these examples demonstrates the potential of the renovation measures beyond functionality and energy consumption reduction. As a whole they state that this potential can be harnessed in all the scope of existing buildings renovations, from single family to multi-family buildings, with the appropriate adaptations to each context.

The aim, and current efforts, of the EBC Annex 56 on “Cost Effective Energy and Carbon Emissions Optimization in Building Renovation” is to provide designers with the tools to narrow the possible solutions - there are several alternatives and options are interrelated - for each building specific context.

Co-benefits

Several terms are used in the literature for side-effects that arise from building renovation such as co-benefits, non-energy benefits (NEBs) and multiple benefits. In Annex 56 it is used the term co-benefits to include all effects of energy related renovation measures besides reduction of energy, CO_2 emissions and costs. These co-benefits can have a significant value but are most often disregarded being the reason for the underestimation of the full value of the renovation works.

In Annex 56 the following co-benefits are considered: 1) Thermal comfort, 2) Natural lighting and contact with the outside environment, 3) Improved air quality, 4) Reduction of problems with building physics, 5) Noise reduction, 6) Operational comfort, 7) Reduced exposure to energy price fluctuations, 8) Aesthetics and architectural integration, 9) Useful building areas, 10) Safety (intrusion and accidents), 11) Pride, prestige, reputation and 12) Ease of installation.

An analysis for the valuation and integration of co-benefits in the decision making process will be performed under a private perspective (from user/promoter/owner point of view). It is therefore relevant to identify and evaluate all the effects that arise from different renovation measures. Furthermore, a survey on existing and ongoing studies about co-benefits from a societal perspective will also be performed, in order to deliver a report targeted to policy makers in order to enable them with knowledge and tools to develop a more comprehensive rationale for energy efficiency policies and programmes.

It is one of Annex 56 goals to evaluate possible forms of integrating co-benefits on the methodology for cost effective energy and carbon emissions optimization. However, these benefits are often difficult and nearly impossible to quantify and measure accurately, which makes it much more difficult to add their contribution into a traditional cost-benefit analysis. Some of the co-benefits occur as a consequence of reduction of energy consumption, CO_2 emissions and costs respectively while others occur as a side effect of the renovation measures (e.g. less noise if change of windows).

Many issues determine whether occupants find energy renovation to be successful. The co-benefits in the case studies include a big variety of issues like better indoor climate, comfort and architecture.

Case studies' specific co-benefits

In the following table the different case studies are listed together with the corresponding benefits derived partly from energy related measures and partly from the non-energy related measures. All the benefits are mentioned by the authors of the case studies.

Country	Designation	Co-benefits from energy related measures	Benefits from non-energy related measures
Austria	Kapfenberg	— Improved thermal quality by reduction of thermal bridges; — Better indoor climate by mechanical ventilation system with heat recovery; — Renewal of old heating and domestic hot water systems improve the operational comfort by a new centralized and automatically controlled system.	— Barrier-free access to all flats by the installation of an elevator and an arcade; — Changed layout of the flats enables new modern living with openable windows to both, east and west sides; — New and larger balconies for all flats; — Improvement of the reputation of the building; — New functional area for the residents.
Denmark	Skodsborgvej 122	— The useable space (first floor) has increased, i.e. the family will use the rooms upstairs far more; — The family can place furniture etc. close to the wall without risking damages (mould) and draught; — This investment ensures that the family can afford other investments in the future.	— The roof construction has been checked and it is clear that it is a good construction which will last for the next 20 – 30 years.
Denmark	Traneparken	— New balconies; — New ventilation system and better indoor climate.	— New green surroundings.
The Netherlands	Wijk van Morgen, Kerkrade	— Reduced exposure to energy price fluctuation; — The overall status of the area has improved.	— The housing association has considerably enlarged the economic and technical “life time” of the housing complex.

Country	Designation	Co-benefits from energy related measures	Benefits from non-energy related measures
Portugal	Pontes Country House	— The renovation measures returned the building living conditions, with levels of thermal and acoustic comfort and air quality consistent with current requirements; — The focus on energy consumption minimization and usage of low embodied environmental impact materials is to be used for marketing purposes, as a sign of pride, prestige and reputation.	— Reuse of an abandoned traditional building, with preservation of its architectural value; — Development, in an economically depressed region, of tourism activities with sustainability principles (optimal use of environmental resources; respect and interaction with the local community; long-term economic operations providing fairly distributed socio-economic benefits to all stakeholders).
Portugal	Bairro Rainha Dona Leonor	— Improved thermal comfort conditions with users now able to heat indoor spaces and keep the interior environment within healthy and comfortable temperatures; — Improved natural lighting with larger glazing areas in living room.	— Aesthetical improvement, returning the dignity and identity of the neighborhood, reducing the social housing stigma; — Better living conditions with more space and more qualified living spaces.
Sweden	Backa rod AB	— New extended balconies; — Repaired façade.	— Water and sewage systems replaced, hot water circulation installed; — New electrical installation; — New bathrooms and kitchens; — Change to parquet floor in living rooms and bedrooms; — New surface finish in the apartments; — Safety doors for the apartments.

Country	Designation	Co-benefits from energy related measures	Benefits from non-energy related measures
Sweden	Brogården	— New balconies; — Larger living rooms; — Better indoor climate.	— Improved accessibility (ground floor); — new water and sewage system; — new electrical installation; — new bathrooms and kitchens; — new surface finish in the apartments.
Switzerland	Les Charpentiers	— Better comfort (noise, thermal); — To avoid thermal bridges, the new thermal envelope wraps balconies. So the living floor area increases.	— Renewing the apartments, new sanitary and kitchen facilities.

All the above renovation projects have been initiated mainly because of other reasons than the reduction of the energy demand. The energy renovation was most often an addition to an anyway renovation of the buildings.

Positive experiences might, if properly communicated to building owners or tenants, help to overcome some of the barriers that homeowners and housing associations are experiencing.

Country / climate specific measures

The table in next page provides an overview of the energy renovation technologies implemented in the 9 shining examples.
All the buildings are insulated, and 8 out of 9 have included new windows in the renovation. Solar heating is exploited either in an active or passive way in 5 of the cases. In most of the cases the heating system was renovated and/or supplied with renewable energy systems.

Summary of the energy renovation features

- All the 9 examples carried out insulation of the envelope in one way or another. One Austrian and one Swiss example have changed the facade with new facade elements including active and passive elements or added an extra module for passive solar use;
- 8 examples have changed windows or glazing;
- 8 examples have ventilation with heat recovery;
- More than half (5) of the 9 examples have solar thermal features mainly for domestic hot water;
- 4 of the 9 cases have improved their lighting by LED or other efficient light;
- 4 of the 9 cases have new or improved heat distribution systems such as thermostatic valves, insulation of tubes or implemented individual meters;
- 6 of the 9 examples have changed or improved their heat supply: two of the examples have solar heating as heating supplement, one with ground coupled heat pump; one example has air to air heat pump (also working as air conditioning system), one new gas boiler is installed and one example has a gas driven CHP system.

As it is seen above, only one example has implemented an air condition system. This is one of the South European examples (in Portugal), where it gets quite hot during summer. In this case the windows area has been increased, improving the use of daylight and increasing heat gains, which are useful for winter. On the other hand, the increase in windows area also led to higher heat gains in summer and necessity of dealing with cooling needs.

Also in this example, heat recovery of the ventilation air is not applied due to the low savings potential because of the relative mild winter in this region of Portugal.

The examples from the Alps countries and the Central European country – The Netherlands – are using solar thermal systems for room heating – active or passive. This may be explained by a comparatively better coincidence of heating demand and available solar radiation.

Energy renovation features		Insulation	Windows glazing	Mechanical ventilation	Solar thermal	PV	Efficient lighting	Air condition.	New/improved heat distribution system	New heat supply
Rainha Dona Leonor, PT	A	1, 2	6		9			√		14
Pontes Country House, PT	A	1, 2,	6	22	9		√		23	15
Kapfenberg, AT	B	1, 2, 3, 4, 5	7	21	8	√				16
Les Charpentiers, CH	B	1, 2, 5	7	21			√		20	17
Wijk van Morgen, Kerkrade, NL	B	1, 2, 3	7	21	9, 10	√				18
Backa röd, SE	C	1, 2, 3	7	21			√		11	
Brogården, SE	C	1, 2, 3	7	21			√		12	
Skodsborgvej, DK	C	1, 2,	7	21	9				13	19
Traneparken, DK	C	1, 2, 3	7	21		√				

(1) Exterior walls insulation
(2) Roof insulation
(3) Ground floor/basement ceiling/basement wall insulation
(4) Active facade elements
(5) Passive facade elements
(6) Windows with double glazing
(7) Windows with triple glazing
(8) Solar thermal
(9) Solar thermal for DHW
(10) Solar thermal building integrated
(11) New radiators and thermostat valves – individual metering of DHW. Already district heating based on 80 % renewable energy.
(12) Individual metering of DHW and electricity. Replacing radiators with heating coils in the supply air. Already district heating based on renewable energy.
(13) New thermostat valves – insulation of pipes Weather compensation and night set back
(14) Air to air heat pump
(15) Ground coupled heat pump
(16) Local district heating and solar thermal panels
(17) Gas driven CHP system
(18) Solar thermal system coupled with condensing gas boiler
(19) New condensing gas boiler
(20) Individual meter
(21) Mechanical ventilation with heat recovery
(22) Mechanical ventilation with heat recovery and free cooling
(23) New wall radiators

South Europe	A
The Alps and Central Europe	B
North Europe	C

Case Studies Location

Country	Site	Building type	Pictures
AUSTRIA	Kapfenberg	Multi family	
DENMARK	Skodsborgvej, Virum	Single family	
DENMARK	Traneparken, Hvalsø	Multi family	
NETHERLANDS	Wijk van Morgen, Kerkrade	Single family	
PORTUGAL	Lugar de Pontes, Melgaço	Single family	
PORTUGAL	Neighborhood RDL, Porto	Multi family	
SWEDEN	Backa röd, Gothenburg	Multi family	
SWEDEN	Brogården, Alingsås	Multi family	
SWITZERLAND	Les Charpentiers, Morges	Multi family	

Case Studies Location

Country	Site	Building type
AUSTRIA	Kapfenberg	Multi family
DENMARK	Skodsborgvej, Virum	Single family
DENMARK	Traneparken, Hvalsø	Multi family
NETHERLANDS	Wijk van Morgen, Kerkrade	Single family
PORTUGAL	Lugar de Pontes, Melgaço	Single family
PORTUGAL	Neighborhood RDL, Porto	Multi family
SWEDEN	Backa röd, Gothenburg	Multi family
SWEDEN	Brogården, Alingsås	Multi family
SWITZERLAND	Les Charpentiers, Morges	Multi family

Kapfenberg

Project summary

Energy concept: Insulation, mechanical ventilation, solar thermal and PV-system

Background for the renovation – reasons

The existing residential building was in high need of renovation. The overall intentions were:

- 80% energy efficiency – 80% reduction of the energy demand of the existing building
- 80% ratio of renewable energy sources – 80% of the total energy consumption of the renovated building should be provided by renewable energy sources
- 80% reduction of CO_2 emissions – 80% reduction of the CO_2 emissions of the existing building

View of existing (small picture) and the renovated building (large picture) (west elevation)

Site: **Johann Böhm Straße 34/36**
8605 Kapfenberg, Austria

Altitude: 502 m

Heating degree days: 3794 (base temp. 20° C)

Cooling degree days: 0

Owner: ennstal SG

Architect: Nussmüller Architekten ZT-GmbH

Energy concept: AEE INTEC

Building description /typology

- Built: 1960-1961
- Residential building with four floors
- On each floor six flats were located
- The living space varied from 20 to 65 m^2
- Total gross heated floor area: 2845 m^2

Contact person: Dir. Wolfram Sacherer
ennstal SG

Important dates: Beginning of the renovation:
March 2012.
End of the renovation:
Jan, 2014

Date completed: Dec. 18, 2013

Building envelope, heating, ventilation, cooling and lighting systems before the energy renovation

Description of building (building situation, building system, renovation needs and renovation options)

The analysed building is a residential building which was built between 1960 and 1961. The four-story building has a length of 65 m (east and west façade) and a depth of 10 m (north and south façade). On each floor nine apartments were located which varied from 20 to 65 m^2 living space. These apartments didn´t meet the current way of living because they were too small. For this reason not all flats were rented.

Building envelope

The existing building was a typical building from the 1960's made of prefabricated sandwich concrete elements without an additional insulation. Only the wood wool panels of the prefabricated concrete elements performed as a slight thermal insulation.

The basement ceiling was insulated with approx. 6 cm polystyrene. The old roof was a pitched roof with no insulation. The ceiling to the unheated attic was insulated with 5 cm wood wool panels.

The existing windows were double glazed windows with an U-value of 2.5 W/m^2K. The missing airtightness of the existing windows caused high infiltration losses.

Heating, ventilation, cooling and lighting systems before retrofit

In the existing building a variety of different heating systems was installed: a central gas heating, electric furnaces, electric night storage heaters, oil heaters, wood-burning stoves and coal furnaces.

The ventilation of the existing building was accomplished by opening the windows; no mechanical ventilation system was installed.

The enormous energy demand caused very high heating and operating costs. A high quality refurbishment of the building with a change in the layout of the apartments should make the building more attractive to new residents and young families.

Façade during the renovation


Facade – before and after the renovation

Element	Area, m²	U-value before renovation W/m²K	U-value after renovation W/m²K
Facade	1463	0.87	< 0.17
Ceiling	711	0.39	< 0.30
Windows, doors	349	2.50	< 0.90
Roof	711	0.74	< 0.10

Energy renovation features

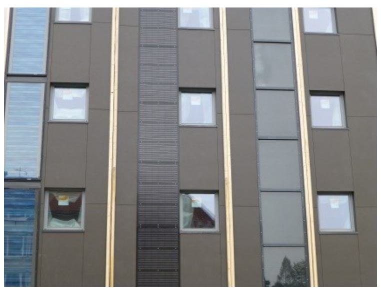
Overall Energy Saving Concept

The retrofit concept is based on energy efficiency measures (reduction of transmission, infiltration and ventilation losses), on a high ratio of renewable energy sources and on an intelligent integration in the existing heat and electricity grid.

Building

Instead of conventional insulation systems the façade in this project is covered with large-sized active and passive façade elements.

These façade elements include on the one hand traditional rear-ventilated constructions (various surfaces possible) and on the other hand active elements to produce energy like solar thermal or photovoltaic panels.



Prefabricated façade elements with integrated active energy production (photovoltaic and solar thermal panels)

The old pitched roof is removed and a new flat roof is established. The roof is highly insulated with approximately 35-40 cm. The windows are already integrated in the prefabricated façade modules and are of high thermal quality (triple glazing).

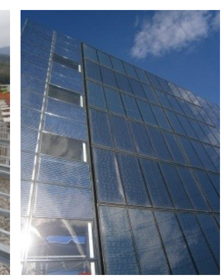
Inside works include among other things also the change of the layout of the flats to make them more attractive to new residents.

Building Services

Heating: The basic heat supply of the renovated building is accomplished by the local district heating. Additionally 144 m² solar thermal panels are installed on the south facade. Heat provided by district heating and solar thermal system is stored in a 7500 liter buffer storage. From the buffer storage a 2-pipe-system (flow and return) brings the heat to the 32 flats where the heat for domestic hot water is stored in a small boiler. Radiators emit the heat in the flats.

Ventilation: A new mechanical ventilation system with heat recovery is installed (heat recover efficiency 65% / SFP 0.45 Wh/m³). The ventilation units are positioned on the flat roof and the existing stacks and installation ducts of the building are used for the ventilation ducts. In one half of the flats the ventilation system is controlled automatically based on the CO_2 concentration, in the other half of the flats the residents can control the ventilation system by a three-stage controller individually.

Photovoltaic: Photovoltaic panels with a size of 550 m² resp. 80 kWp are installed on the roof on a steel construction in form of a wing. Additionally 80 m² resp. 12 kWp are installed on the south facade.



Mounting of the photovoltaic panels on the roof (left picture), pv and solar thermal panels on the south façade (right picture)

Calculated Energy Savings, CO_2 reductions and Life Cycle Costs

Energy demand for heating and hot water before and after renovation:

Calculated energy demand:	
before renovation:	337 MWh/year
after renovation:	85 MWh/year
calculated savings:	252 MWh/year

Left building part already renovated – right building part in the middle of the renovation

Calculated energy savings:

The transmission heat losses from the building envelope can be reduced from 337 MWh/year (existing building) to 85 MWh/year (renovated building). This means energy savings of 252 MWh/year.

The infiltration heat losses can be reduced from 89 MWh/year (existing building) to 47 MWh/year (renovated building). This means energy savings of 42 MWh/year.

In total 294 MWh/year can be saved for heating and domestic hot water.

As a result of the renovation the usable energy gains in the building (internal and solar gains) are reduced from 126 MWh/year to 84 MWh/year. This means 42 MWh/year less energy gains are usable after the renovation.

As a consequence of that the calculated total energy savings are 252 MWh/year.

Calculated energy production:

The calculated energy production of the solar thermal system is 39.5 MWh/year; the energy production of the photovoltaic panels is about 80 MWh/year.

Solar thermal and PV panels on the south facade

Total Renovation Costs: 4.3 Mio €

Overall improvements

Non-energy benefits

- New and larger balconies for all flats:
    - Improvement of the reputation of the building
    - New functional area for the residents
    - Improved thermal quality by reduction of thermal bridges
- Barrier-free access to all flats by the installation of an elevator and an arcade
- Changed layout of the flats enables new modern living with windows to both, east and west, sides
- Better indoor climate by mechanical ventilation system with heat recovery
- Renewal of old heating and domestic hot water systems improve the operational comfort by a new centralized and automatically controlled system

Indoor climate technical improvements

The indoor climate is improved due to:

- mechanical balanced ventilation with heat recovery and a carefully adjusted supply temperature
- Less heat losses and draught through walls, windows and doors

Different steps of the building renovation process: installation of the building services, assembling of the prefabricated façade modules, almost finished building envelope (f.l.t.r.)

Assembling of the prefabricated façade modules on the west facade

Summary and Lessons Learnt

Summary
The existing residential building is renovated with a new façade (prefabricated active and passive elements), new windows, new roof (flat roof instead pitched roof) and new building services.
A new heating system (local district heating and solar thermal system on the south façade of the building) and a new mechanical ventilation system with heat recovery are installed.
Photovoltaic panels on the roof and on the south façade for the electric energy production were also installed.
By those measures following objectives of the renovation should be achieved:
- 80% energy reduction
- 80% ratio of renewable energy sources
- 80% reduction of CO_2-emission

Lessons Learnt
All asked tenants lived in the building before the renovation and 85% also during the renovation of the building.
The expectations of the tenants to the retrofit were generally satisfied. The tenants were also satisfied with the housing association and the different companies which carried out the renovation.
Assessing their housing situation some tenants criticized the natural lighting in the apartments, the temperatures at the beginning (too cold) and the noise because of the renovation works of the second construction phase.
The tenants were satisfied with the information they received regarding the mechanical ventilation system and the heating and domestic hot water preparation.

References: all AEE INTEC

Left building part: finished renovation; right building part: still in renovation

A few days later – building envelope of the right building part almost finished

Skodsborgvej, Virum, Denmark

Project summary

Energy concept: Total renovation to reduce energy consumption and improve indoor climate

Background for the renovation – reasons

- The double-storey detached house from 1927 is situated in Virum, 20 km north of Copenhagen. In December 2011, a small family bought the house. The family wanted to renovate the house in order to enjoy the house more in the future. Therefore, the family contacted an energy adviser who audited the house, and together they made a plan for the energy renovation of the house.
- They wanted an energy renovation because it was difficult to heat the house to a satisfactory temperature, and the house had a bad indoor climate and also they wanted a bigger bathroom in the basement. Therefore, they borrowed money to finance these renovation measures.
- As a result of the cooperation with the energy adviser, the energy renovation was given high priority, both because it would save money and provide comfort and improve the indoor air quality.

Figure: House seen from the road – before renovation and from the garden after renovation

Site:	**Skodsborgvej, Virum, Denmark**
Altitude	27 m
Heating degree days:	2906 (base temp 17 °C)
Cooling degree days:	0
Owner:	Thomas Brørup & Susanne Krøgh Rasmussen
Architect:	None
Engineer:	Susie M. Frederiksen

Building description /typology

- Two-storey villa with red bricks and red tiled roof, built in 1927
- Energy label G
- Gross heated floor area: 121 m^2

Contact person: Susie M. Frederiksen, Danish Knowledge Centre for Energy savings in buildings

Important dates:
The house was renovated in1941, 1951, 1954
December 2011: The family bought the house
2012: Renovation was planned and carried out.

Date of template Completed: 6.1.2014

Building envelope, heating, ventilation, cooling and lighting systems before the energy renovation

Building envelope before renovation

The first floor had a very low level of insulation and suffered from draught, which made it quite uncomfortable during winter. For the same reasons it was almost impossible to heat the first floor to a satisfactory temperature. The mansard walls were partially insulated (ranging from 0 to 100 mm) and the roof spaces were completely uninsulated. The collar beam ceiling was insulated with 200 mm of insulation except the pediment towards the road which was insulated with only 100 mm. None of the roof spaces were insulated - neither on the wall towards the rooms nor on the floor towards the rooms of the ground floor. The front tip towards the road consisted of an uninsulated solid brick-wall. The rooms on the first floor beyond the above mentioned were insulated with cellotex.

The bathroom in the attic was insulated with 25 mm of insulation

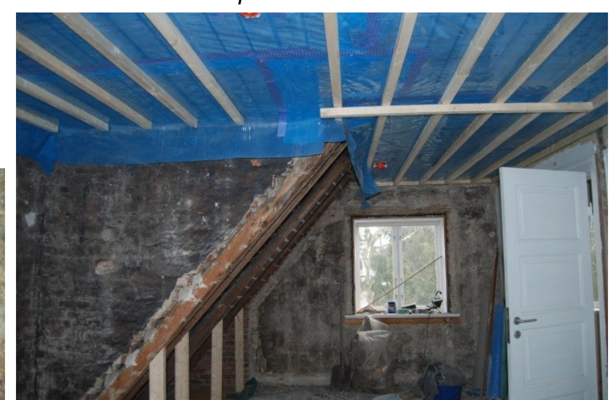
The ground floor and gable cavity walls were already insulated with injected foam, which was often used during the 1960-70s. The insulation was surprisingly found to be intact.

The windows were replaced by a first generation of double glazing during the 80s.

Heating, ventilation, cooling and lighting systems before renovation

The house was heated with central heating from 1954 supplied from a gas boiler from the 80s. The house had no ventilation system, i.e. natural ventilation was used.

Above: Seen from the garden before renovation
Below: The new vapour barrier on the loft



From left tp right: 1. The old gas boiler and hot.water tank.
2. Installation of the new B-labeled balcony door
3. Existing insulation in the loft

Energy renovation features

Energy saving concept

Overall renovation in order to reduce the energy consumption and improve the indoor environment

Technologies

- Insulation of envelope
- New glazing in windows
- Solar heating plant
- Condensing gas boiler
- New valves
- New insulation of pipes
- Balanced ventilation with heat recovery

Building

U-values for constructions before/after renovation can be seen in the table.

- Ceiling - from 100 to 400 mm
- Sloping wall – from 0/25/100 mm to 200 mm
- Roof spaces in attic - from 0/25/50 mm to 300 mm
- Solid brick walls – from 0 mm to 100 mm (inside)
- Light walls and flat roof – from 25 mm to 150 mm
- Double glazed windows/doors - replaced by low energy windows/doors
- Balcony door – replaced by low energy balcony door

Systems

- Gas boiler – replaced by modern condensing boiler
- Radiator valves – replaced by thermostatic valves w. electronic control
- Installed weather compensation and night setback
- Insulation of hot water, heating system and other pipes from existing 0/20 mm old insulation to 40 mm new insulation

Construction	U-values Before W/(m^{2}K)	U-values After W/(m^{2}K)
Collar beam ceiling	0,30	0,14
Sloping walls (manzard walls)	1,00	0,16
Roof spaces in attic	0,90	0,11
Solid brick walls	1,65	0,29
Light walls and flat roof	1,00	0,20
Windows and balcony door	2,80	1,40

Figure: U-values before/after renovation

Renewable energy systems

- Solar heated water - 4.7 m^2 solar panels and 300 liter solar tank

Right: Pediment in the bedroom with new balcony door - almost ready to move in.

Achieved Energy Savings, CO_2 reductions and Life Cycle Costs

Energy consumption, calculated	Before renovation	After renovation
Energy consumption	39941 kWh (3631 m^3 gas)	21087 kWh (1917 m^3 gas)
Energy consumption pr. m^2	327 kWh/m^2	172 kWh/m^2
Useful m^2	121 (but very cold)	121 (now 1. floor is comfortable)
Energy label	G	D

Costs	DKK/EUR	DKK/m^2 / EUR/m^2
Craftsmen incl. consultants	330.000 / 44.236	2705 / 363
Subsidies (Craftsmen-deduction and from energy-utilities)	48.000 / 6.434	393 / 53
Total renovation price (after subsidies)	282.000 / 37.801	2330 / 312
Increased value of the house (due to better energy label)	306.000 / 41.018	

Calculated:
The calculated savings are approx. 18.000 kWh – which means that the energy bill is cut by approx. 47%.

User evaluation:
In the first heating season the energy bill was cut by 25% and the heated area in reality increased by 100%.

Investment and savings:
Total investment (DKK/EUR): 282.000 / 37.802
Savings pr. year (DKK/EUR): 15.000 / 2.010
Simple payback (years): 19

Energy renovation	Savings kWh/a	Reduction ton CO_2	Savings DKK/EUR pr. year
Insulation of roof spaces in attic (space under the roof slope)	1850	0.4	1450/194
Insulation of mansard walls (sloping walls) 1st floor	1800	0.4	1400/188
Replacement of glazing in windows and balcony door in the pediment	2000	0.4	1600/214
Solar heating plant for domestic hot water	2350	0.5	1850/248
Ventilation with heat recovery	4700	1.0	3700/496
Old gas boiler replaced by new condensing gas boiler	5300	1.1	4200/563
Replacement of thermostatic radiator valves to new ones with electronic control			
Insulation of domestic hot water pipes and valves	2000	0.4	1600/214
Weather compensation and night setting and balancing/ controlling of the system	2200	0.5	1750/235

Overall improvements, experiences and lessons learned

Energy

Annual savings: 18.000 kWh

Indoor environment

- No draught - no cold walls - no moisture - no mould
- No condensation on the glazing of the windows
- The air is being changed without opening the windows
- Before renovation it was not possible to heat the first floor
- Now, the house is often heated only by the passive solar energy – even in winter
- Thermostatic valves ensure that the temperature is right

. **Non-energy benefits**

- The useable space (first floor) has increased, i.e. the family will use the rooms upstairs far more
- The family can place furniture etc. close to the wall without risking damages (mould) and draught
- Improvement of energy label leads to increased house price
- This investment ensures that the family can afford other investments in the future
- The roof-construction has been checked, and it is clear that it is a good construction which will last for the next 20 – 30 years.

Decision process – barriers that were overcome

As soon as the family bought the house, they realised that the house was not very healthy to live in – and heating it was expensive. It was so cold upstairs, that they had to wear outdoor clothing. The cold walls also meant moisture and mould. So it was an easy and quick decision, that the first floor had to be renovated with more insulation. The process started in December 2011, where the energy adviser made the first audit and made a plan for a total energy renovation; the family chose to carry out almost the entire plan.

The energy renovation was filmed to be used as a ”good example” and the energy savings were calculated by the Danish Energy authorities. In June 2012 the family could move into their new first floor – after having done the decorating themselves. The family is really happy that they chose to spend money on the energy renovation: “The new comfort is really great value for us – and we can only advise other house owners to do the same”. It was a relatively easy process for the family. They hired an energy adviser who had knowledge about both the buil-ding envelope and the technical installations and could plan the renovation and control the work process with various craftsmen. “We are really happy that we made initiated the renovation immediately – and that we took the whole energy renovation package. We no longer have doubts that this is a good house and we really enjoy living in it!”, says Thomas Baarup.

Insulation of mansard walls and lost space walls in attic incl. vapour barrier and internal insulation of the pediment

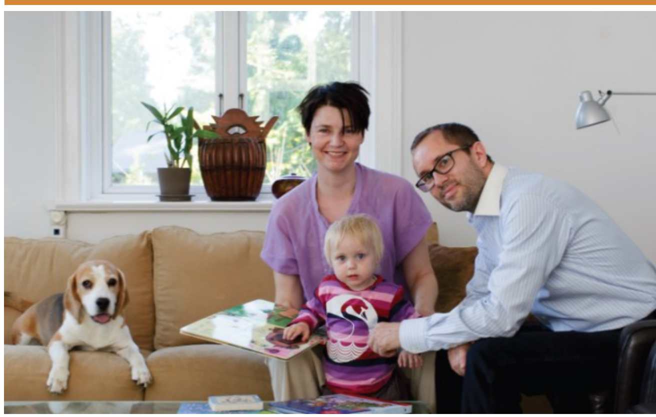
Non-energy benefits

Advantages:

- Space better used (first floor)
- No draught, no cold wall, no moisture or mould
- Improvement of energy label leads to a higher possible price of the house.

Summary

Thomas and Susanne's new house spent a lot of energy, and they could not use the first floor as it was very cold and humid. Therefore, they contacted an energy adviser, who made a plan for the energy renovation of the house, which included as well the building envelope, heating system, ventilation and renewable energy. Susanne and Thomas chose to implement insulation of the mansard walls, and replacement of glazing in the windows and of the balcony-door. Furthermore they replaced the existing gas boiler with a new condensing boiler. A solar heating plant produces domestic hot water. A new ventilation plant with heat recovery is installed, and the pipes are insulated. Thermostatic valves are renewed, and the heating system is optimized. The family has thereby reduced the energy bill by approx. 50%, and improved indoor climate, so they can now use the entire house. The savings actually pay the loan for the renovation and the price of the house is estimated to increase just as much as the cost of the energy renovation.



The dog Emil, Susanne, the daughter Elisabeth and Thomas enjoy their new home.

Acknowledgements

Craftsmen:

Carpentry work was done by:
Thomas Guld, energy adviser, thatcher and carpenter
www.thomasguld.dk

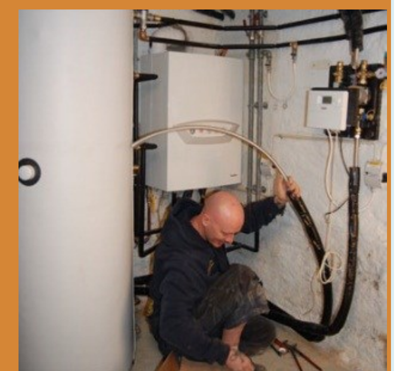
Plumbing work was done by:
Energy Adviser Morten Kühlmann
Triton Plumbing aps
www.tritonvvs.dk

The masonry work was done by:
Energy Adviser Ib Larsen
www.murerbiksen.dk

Electrical work was done by:
Electrician Kim Roy Kronkvist-Hansen
Roy Construction

Ventilation Work was done By:
PRO Ventilation
www.proventilation.dk
HMN Natural Gas A / S
www.hmn.naturgas.dk/kunde/sparenergi/

Installation of the new heating system.



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[1] www.byggeriogenergi.dk

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[3] http://www.byggeriogenergi.dk/energirenovering-paa-film/vejledning/32435

Traneparken, Hvalsø, Denmark

Project summary

Energy concept: Insulation, ventilation, control, PV-system

Background for the renovation – reasons

The buildings had to be renovated because they were worn down. The overall intentions were to:

- Renovate buildings because it was needed – especially the concrete external walls
- Improve energy conditions (insulation – windows – doors)
- Improve indoor climate
- Improve flats by adding and external balcony
- Improve the outdoor areas

2 of the 3 blocks at Traneparken. The one on the left not yet renovated – the other after renovation.

Site: **Traneparken 2-20**
4330 Hvalsø, Denmark

Altitude: 47 m

Heating degree days: 2906 (base temp. 17 ° C)

Cooling degree days: 0

Owner: Hvalsø Boligselskab

Architect: ARKIPLUS 1969

Engineer: Sigfried Lorentzen Rådgivende Ingeniørfirma

Building description /typology

- 3 blocks of prefabricated concrete sandwich element buildings
- Built: 1969
- General information: Energy label E
- Gross heated floor area: 5293 m²

Contact person: Flemming Østergaard, Building Association Zealand

Important dates: Renovation start: November 1, 2011. End of the renovation: October 1, 2012

Date completed: Dec. 23, 2013

Building envelope, heating, ventilation, cooling and lighting systems before the energy renovation

Description of building (building situation, building system, renovation needs and renovation options.

Traneparken consists of 3 multistory blocks of flats situated in the village Hvalsø, 55 km west of Copenhagen. Each block has 3 storys and altogether 66 flats. The residents are an average part of the Danish population – except for 48 % being singles (rather small apartments). However – there is a rather big change of residents every year in Traneparken.

Building envelope

The buildings are typical 1960- buildings made of prefabricated enforced sandwich concrete elements with approx. 50 mm insulation.

Between the windows are panel walls which were insulated with approx. 6 mm insulation.

Floor insulation to basement was approx. 45 mm. The roof was insulated with approx. 190 mm. Windows were double glazed with U-value 1.8.

Heating, ventilation, cooling and lighting systems before retrofit

The buildings are heated by district heating let into the basement of block A to a 200 kW plate heat-exchanger. From there it is distributed to the 3 blocks.

There are pre-insulated domestic hot water tanks in each block. Altogether there are eight 300 liter tanks.

The flats are ventilated by a mechanical exhaust air system from bathroom, toilets and kitchens.

Light: There are energy-saving-bulbs in all indoor lights on the staircases. It is equipped with automatic switch-off controls based on presence detectors. Outdoor light has automatic daylight switch-off.

The buildings seem rather “grey and boring” with problems from facades, windows, roofs, etc. The indoor climate was bad and the energy consumption was unacceptable large.

It was the intention that the renovation will make Traneparken more attractive for existing and new residents.

Facades – before and after:

Element (only block A)	Area m²	U-value before renovation W/Km²	U-value after renovation W/Km²
Exterior walls	486	0.66	0.15
Floor over basement	361	0.66	0.66
Panel Wall	106	0,7	0,11
Windows, doors	205	2,4	0.8
Roof	333	0,2	0.09

Energy renovation features

Energy saving concept

The goal was to renovate the buildings because they were worn down, so the overall intention was to:

- Renovate buildings because it was needed - the concrete external walls were weakened by deterioration. At the same time external balconies should be added to improve the flats.
- Reduce the energy consumption
- Improve indoor climate

Building

- The exterior walls have been renovated: Supplementary thermal insulation is added to the outside of the exterior walls. The external insulation is continued to the base of the house to reduce thermal bridges. Cost: 12.5 million DKK = 1.67 million € (incl. VAT)
- The roofs are renovated and insulated. Cost: 4.2 million DKK = 0.56 million € (incl. VAT)
- The windows and doors are replaced with 3 layers low-energy windows. Cost: 0,85 million DKK = 114,094 € (incl. VAT, excl. installation).

Systems

Heating: Nothing changed

Ventilation: The flats are now ventilated by a balanced mechanical ventilation system with heat recovery. Exhaust air from bathroom, toilets and kitchens and supply air to the living rooms.

Lighting: No changes of the lighting - it is already up to date.

Element (only block A)	After renovation
Exterior walls	Plus 190 mm insulation plus exterior solid standard bricks Now: 240 mm
Filling panels between windows	Plus 285 mm insulation plus exterior solid standard bricks Now: 330 mm
Windows, doors	3-layer low-energy windows with aluminium – wood frame
Roof	Plus 250 mm Now: 435 mm

Renewable energy systems

Solar panels are installed for electricity production.

Achieved Energy Savings, CO_2 reductions and Life Cycle Costs

Energy consumption for heating and hot water before and after renovation:

Calculated energy consumption:

before renovation:		728 MWh/year
after renovation:		502 MWh/year
calculated savings:		226 MWh/year

Actual energy consumption measured over a 12 months period:

before renovation	2011 - 2012	736 MWh
after renovation	2012 - 2013	506 MWh
actual savings:		230 MWh

Non energy benefits: More beautiful buildings – better ventilation and balconies

Renovation Costs

Craftsmen	**38 million DKK** **5.1 million €**	**7525 DKK/m²** **1010 €/m²**
Consultants	11.3 million DKK 1.51 million €	2238 DKK/m² 300.4 €/m²
Total	49.3 million DKK 6.61 million €	9762 DKK/m² 1310 €/m²

Calculated energy savings and PV production

Energy savings by reduced heat loss from the building envelope is 120 MWh/year.
Energy savings by reduced ventilation loss is 106 MWh/year.

Total annual energy savings : 226 MWh/year.

Increased running costs for the ventilation system: 100.000 DKK/year = 13,400 €/year.

PV electricity production: 30.000 kWh/year = 60.000 DKK/year / 8054 €/year (~ electricity consumption in the common laundry).

Actual production from PV:
1st year of operation: 38159 kWh.

Overall improvements, experiences and lessons learned

Energy

Savings: 226 MWh/year.

PV production: 30 MWh/year

Indoor climate technical improvements

The indoor climate was improved due to:

- mechanical balanced ventilation with heat recovery and a carefully adjusted supply temperature
- Less heat loss and draught through walls, windows and doors

Economics

It was important for the economy that the buildings needed renovation because of beginning deterioration. Therefore a large part of the renovation could be financed from funding available for improving the present situation – a Danish fund for social housing was used for this purpose: “Landsbyggefonden”.

Decision process – barriers that were overcome

In social housing projects in Denmark a majority of the tenants has to agree on the decision. This means very much information, many meetings etc.

Non-energy benefits

The renovation has resulted in:

- New balconies
- New green surroundings
- Ventilation – better indoor climate

Economic consequences for the tenants

Rent before: 698 DKK/m^2/year = 93.7 €/m²/year

Rent after: 786 DKK/m^2/year = 105.5 €/m²/year

Increase: 88 DKK/m^2/year = 11.8 €/m²/year

Energy savings: 226 MWh/year

Energy price: 700 DKK/MWh = 94 €/MWh

Savings: 226 x 700=158.200 DKK = 31 DKK/m^2/year = 4.2 €/m²/year

Indoor climate

Practical experiences of interest for a broader audience:

The tenants are satisfied with the improved indoor environment. For example: The benefits of the ventilation system: “now we don’t have to care about opening windows to change the air” - and the costs for heating has been considerably reduced, while the thermal comfort in the dwellings has improved considerably.

A few tenants claim that the air is now too dry – during the winter season.

It is expected that the former problems with mold will not re-occur with the improved ventilation.

Users evaluation

The users are very content with:

- The new balconies – they increase the useful area of the flats
- “The buildings are more beautiful now so, we take better care”
- The air quality
- The renovation process

General data

Summary of project

Three existing building blocks have been renovated with new facades, new windows, additional insulation on the roof, mechanical ventilation with heat recovery and a PV installation on the roof.

The consultants succeeded in informing the tenants and presenting the project in detail to them well before the construction started. During the renovation process they were also good at informing and just talking with the tenants. The tenants showed great patience; probably because of the good information they had been given.

Traneparken has become a more attractive place to live and thus it will be easier to find tenants for the apartments. It is also expected that the tenants will take better care of their homes and the surroundings.

Figure: 190 mm insulation plus exterior solid standard bricks. Energy windows – aluminium – wood, 3-layer energy glass. In the panel walls: 285 mm insulation plus exterior solid standard bricks.

Experiences/lessons learned

It is important that the tenants get what they expect, so from the beginning it is necessary to spend a great deal of effort on making sure that the expectations are adjusted to what can be met in practice.

It takes longer time to plan and carry out a renovation than a new construction, mainly because the apartments are inhabited.

The inhabitants/tenants have to be part of the decision process (tenants democracy is given by law in Denmark). The time schedule is important –the tenants need to know when something is going to happen in their dwelling.

It is cumbersome to carry out work in apartments, where people live – the individual craftsman need to be considerate. There are sometimes conditions in the individual dwellings, which are not known beforehand, so the project has to be adapted to these – and there has to be money enough for this flexibility. In this case there were sufficient financial room for particular considerations in the individual dwellings and to solve unexpected problems, what always occur in a renovation project.

The security at the building site has to be the very best – it has to take into account the tenants and especially children living at the building site. The consultants and the contractor succeeded at this in the Traneparken project.

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[1] Notat, Martin Nørmarkve

[2] Helhedsplan for Traneparken, Hvalsø Boligselskab

Wijk van Morgen, Kerkrade

Project summary

The project consists of 153 social-rental dwellings, built in 1974, that have been renovated to Passive House standard. As a precondition the renovation has taken a mere 8 working days per house, due to replacement of the facades and roof by complete, pre-manufactured elements. Solar energy plays an important role, in particular photovoltaics and solar thermal energy.

Energy concept: Passive House standard,balanced mechanical ventilation with high efficiency heat recovery, high efficiency condensing boiler, roof integrated PV and solar thermal collector.

Renovated dwellings

Site: Wijk van Morgen, Kerkrade
Hagendorenstraat 2
NL 6460 AC Kerkrade

Owner: HEEMwonen
Erpostraat 1
NL 6460 AC Kerkrade

Architect: Teeken Beckers
Architecten bv
Hagendorenstraat 2
NL 6436 CS Amstenrade

Engineer: WSM Heythuysen

Building description /typology

- Built 1974
- 70 appartments (two storeys)
- 83 single-family houses

Contact person: Maurice Vincken,
HEEMwonen

Important dates:
Start of the demonstration project: 2011
Completion of the demonstration project:
21 december 2011
Start of the main project: June 2012
Completion of the main project: June 2013

Date completed: November, 2013

Building envelope, heating, ventilation, cooling and lighting systems before the energy renovation

Description of building (building situation, building system, renovation needs and renovation options.

The houses are located in Kerkrade, a city at the Dutch-German border near Maastricht. They were built in 1974 as social rental houses, of which 70 apartments and 83 one-family houses. The party walls are load-bearing brickwork, the floors are concrete slab floors.

Building envelope

In the not renovated situation, the building envelop consists of two façade elements made of wood. The windows have single panes; there is no insulation and the houses have an individual gas fired central heating system. As the energy demand was high, but the basic construction and floor plans of the houses were quite sufficient, it was decided to renovate the houses to such a level that the social, economical and technical lifetime was extended with an additional 40 years.

Heating, ventilation, cooling and lighting systems before retrofit

Also aspects of building technology, long-term maintenance, improvement of the living environment, and sustainability were taken into consideration when making the plans. In addition, the tenants were supposed to continue their livings in the house during the renovation. Consequently, a renovation technology was developed based on full replacement of the roof and façade elements by brand new, prefabricated elements, the roof elements having the solar photovoltaic and thermal systems integrated.

The houses before renovation

Energy renovation features

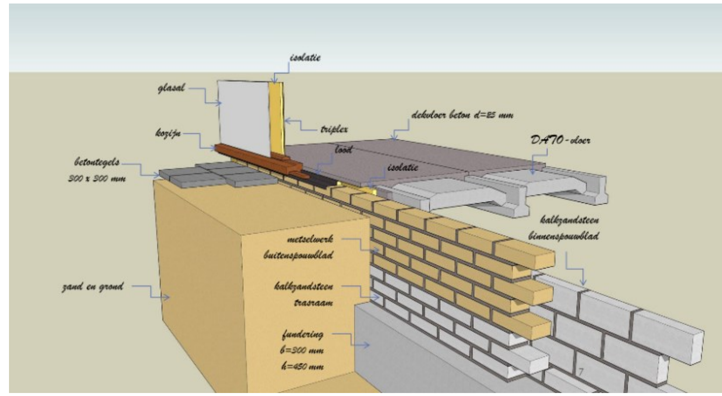
Energy saving concept

The building shell has been improved to passive house standard. The images at the right show the original construction of the walls, ground floor and foundation (before renovation) and the construction as it is after renovation.

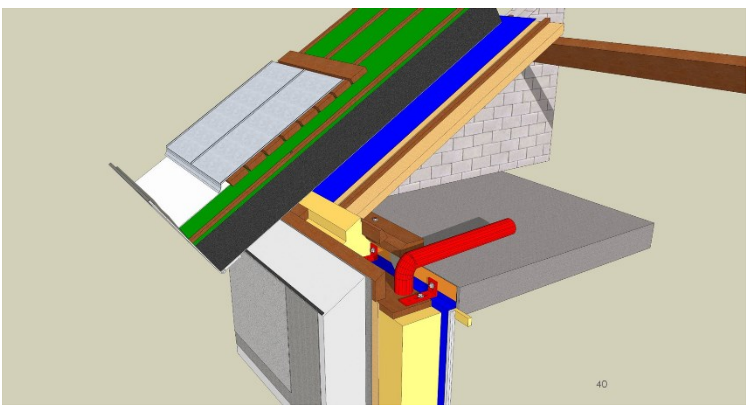
As usual with passive houses and passive house renovations, the houses have a balanced mechanical ventilation system with high efficiency heat recovery

Space heating and domestic hot water are provided by a high efficiency condensing boiler and a solar thermal collector.

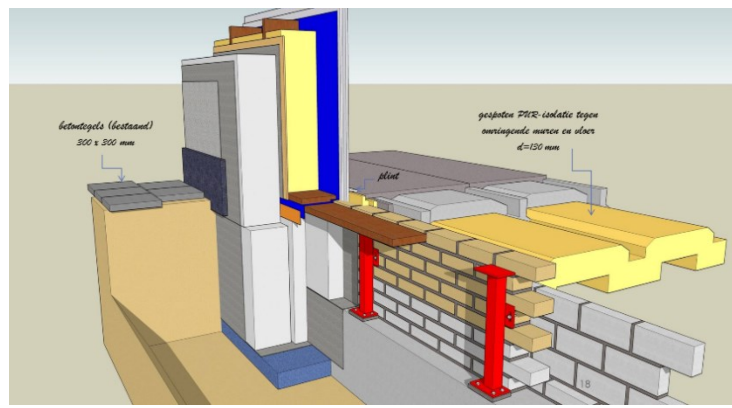
The houses have been provided with new roof elements, including prefab integrated solar collectors and photovoltaic modules



Wall-floor construction, before renovation:



Roof-upper floor construction after renovation to passive house standard



Wall-floor construction after renovation to passive house standard

Achieved Energy Savings, CO_2 reductions and Life Cycle Costs

Energy and cost savings from the renovation

Energy savings costs per Month:

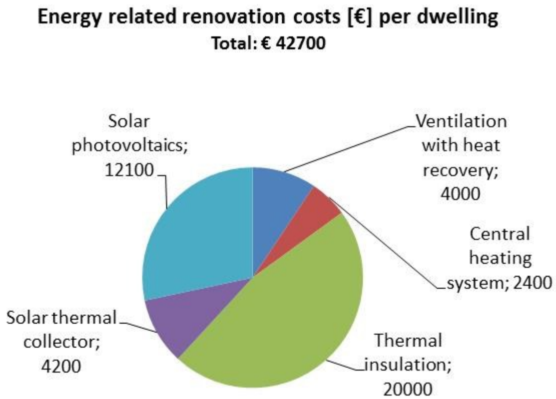
	Natural Gas:	€ 53
	Electricity:	€ 48
	Total savings:	€ 101

Rent increase per month:

	Renovation:	€ 40
	Solar system:	€ 24
	Total:	€ 64

Net economical savings for the tenants per month:

	Total:	€ 37



Renovation Costs

Energy related renovation costs per dwelling	
Ventilation with heat recovery	€ 4.000
Central heating system	€ 2.400
Thermal insulation	€ 20.000
Solar thermal collector	€ 4.200
Solar photovoltaics	€ 12.100
Total	€ 42.700

Overall improvements, experiences and lessons learned

The main goal of the renovation was to improve the energy standard of the house in such a way, that the living costs of the tenants do not increase, whilst the comfort and energy consumption of the house should be brought to the passive house standard, whereas the remaining "life time" of the houses should be extended to another fifty years. Furthermore, the inconveniences for the tenant during the renovation process should be as least as possible. Consequently, a concept has been developed for carrying out the renovation in a mere eight working days, with two extra days for cleaning up the building site. This concept has proven to be feasible.

Economic consequences for the tenants

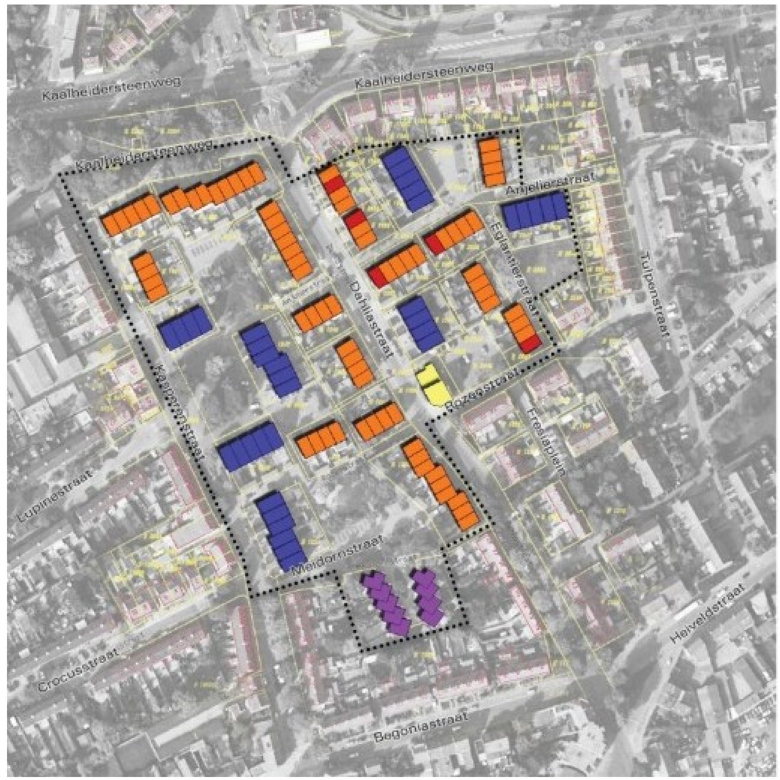
After renovation, the (calculated) net profit for the tenant should be € 37 per month (of course depending on the individual household energy consumption).

Lessons learned:

- success of the project is very much depending on the full support by the tenants and by the board of the housing association
- Participants in the process should learn to leave the common, well-known solutions and to think "out of the box" for new solutions of the problems.
- The project ambitions must be high and should not be weakened during the process.

Co-benefits

- The housing association has considerably enlarged the economical and technical “life time” of the housing complex
- The tenants have the advantage of lower living costs in a more comfortable house, as the savings on enegry costs are higher than the rent increase
- The overall status of the area has improved.



General data

Summary of project
The project consists of 153 social-rental dwellings, built in 1974, that have been renovated to Passive House standard. As a precondition the renovation has taken a mere 8 working days per house, due to replacement of the façades and roof by complete, pre-manufactured elements.
Solar energy plays an important role, in particular photovoltaics and solar thermal energy.

Acknowledgements
HEEMWonen, Kerkrade
Platform31, Den Haag
EnergyGO, Alkmaar
BAM Woningbouw, Bunnik

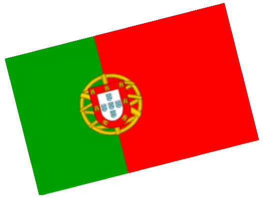
Figure: The houses after completion

References

[1] **www.westwint.nl**

[2] **www.bamwoningbouw.nl**

[3] **www.energiesprong.nl**



Pontes country house

Project summary

Background for renovation and energy concept

The abandoned house needed to be thoroughly renovated in order to become livable again. Taking advantage of recent growth in tourism activities all over the surroundings, the renovated building will be used for sustainable tourism activities. During the renovation works it will be subjected to:

- Structural renovation and reinforcement (wooden and stone structures)
- Energy efficiency measures in the envelope (insulation of walls, roof, windows, doors)
- Recovery of housing conditions (present state is not habitable)
- Installation of efficient energy systems (space heating and domestic hot water)

Country house before intervention (south east and southwest facades)

Site: **Lugar de Pontes Castro Laboreiro, Melgaço**

Altitude: 726 m

Heating degree days: 2770 (base temp. 20° C)

Owner: **Carlos Moedas**

Architect: Inês Cabral

Engineer: André Coelho, Ecoperfil, Sistemas Urbanos Sustentáveis, Lda.

Building description /typology

- Located in a small rural village in the hills of Peneda in the northwest of Portugal
- Individual vernacular stone (granite) wall house
- Originally built in 1940
- Currently inhabitable, almost in ruins
- Gross heated area: 180 m²

Contact person: André Coelho

Important dates: Building permit in July, 2013. Estimated start of the renovation works in October 2013

Date of template Completed in 20-01-2014

Building envelope, heating, ventilation, cooling and lighting systems before the energy renovation

Description of building (building situation, building system, renovation needs, renovation options)

The Pontes country house shares the patio with the commune stove and was bought in 2012 for sustainable tourism activities and aims at providing accommodation with sustainability principles (optimal use of environmental resources; respect and interaction with the host communities; viable, long-term economic operations, providing socio-economic benefits to all stakeholders that are fairly distributed). Its original state was almost a ruin, severely degraded in its wooden elements, lacking windows in some places, and affected by rot and moisture. Inside temperatures closely followed exterior variations, and frequent chilled air drafts. Moisture deterioration was present in wood structures, both in floors and roof, and also through seepage and/or condensation on walls.

Building envelope

Uninsulated granite stone walls (without coverings), wood structure floors and roof (not insulated), ground floor in direct contact with soil (animal shelter), single glazed windows with wooden and frames (degraded). Original stone walls were massive but loosely arranged in some areas (need of structural reinforcement)

Heating, ventilation, cooling and lighting systems before retrofit

The house was not serviced by running water, electricity or phone access. Heating was provided by a fireplace, also used for cooking. The house was not served by any support system, including lighting, water supply and sewerage. Renovation potential was at its maximum, in order to gain confortable living conditions.

The building has a strong architectural image, very much linked with the region's traditional life style and architecture, but without suitable comfort conditions it will not attract visitors. The global intention of the renovation is therefore to provide that comfort, at a minimum energy and resource expenditure, according to construction sustainability principles, while maintaing the building's identity and historical features.


Roof condition and characteristics

North elevation

Element	U-value before renovation (W/m²°C)	U-value after renovation (W/m²°C)
Exterior walls	1.82	0.45 (average)
Ground floor	Direct contact with soil	0.5 (average)
Doors	2.7	0.81
Windows	4.6	2.05
Roof	4.55	0.23

Energy renovation features

Energy saving concept

The main principles of the energy saving concept were limiting the heat losses during winter, use energy efficient heating equipment and take advantage of the sunlight to capture the thermal energy. Low embodied energy materials were preferred.

Technologies

- Building insulation
- Windows replacement
- Balanced mechanical ventilation with heat recovery and free cooling
- Geothermal heat-pump
- Efficient lighting
- Thermal solar panels for domestic hot water (DHW)

Building

- Walls: creation of an interior closed air space, placement of insulating cork boards (ICB) and light covering elements (in general MDF boards over wood support). This solution allows maintaining the existing materials and avoids new construction while preserving the external architectural identity of the building.
- Roof: wooden false ceiling, creation of closed air space, structural oriented strand board (OSB), placement of ICB , water tight covering.
- Floor: ICB under floor slab
- Windows: replacement of all existing windows and placement of new double glazed ones with low emissivity layers, within wooden frames (4+16+6 mm).

Strategy	Impact / purpose
Reinforcing structural stone walls	Maintain structural elements, avoiding new construction (less environmental impact). Maintenance of historical features.
All interior and roof structures made of wood	Use of a local, low embodied energy material. Use of waste wood (MDF and OSB). Maintenance of historical features (although with new wood elements).
Creation of closed air spaces in walls and roof	Additional free insulation (air has good thermal resistance) and use of these spaces as service ducts, avoiding waste generation in infrastructure placement.
No ceramic bricks and no cement based mortars	Use of concrete bricks, which are less energy intensive than ceramic bricks, and use of lime based mortars (eliminating the energy intensive cement in used mortars)

Systems

- Heating: 16 kW geothermal heat pump (space heating and DHW) and heat distribution with radiators
- Cooling: Natural ventilation, free cooling and wooden shutters on windows
- Ventilation: Heat recovery box with 91% efficiency. Fresh air supply and exhaustion of all spaces.
- Lighting: Up to date fluorescent and LED based lighting

Renewable energy systems

- Thermal solar panels for DHW production (6.8m^2)

Energy Savings, CO_2 reductions and Life Cycle Costs

Energy needs [1]	Before renovation	After renovation
Heating needs	477.9 kWh/m².y	123.8 kWh/m².y
Cooling needs	12.1 kWh/m².y	10.4 kWh/m².y
DHW needs	54.8 kWh/m².y	3 kWh/m².y [2]
Energy label [3]	F	A+

[1] Only values for calculated energy needs are presented once the original condition of the building didn't had non-renewable energy consumption and wasn't able to provide comparable thermal comfort conditions.

[2] Value for DHW needs already includes the solar thermal contribution

[3] Buildings energy certification scheme in Portugal ranks the energy performance of each building from level G to level A+, being the first the less efficient. The higher level A+ means that the building calculated non-renewable primary energy consumption is under 25% of the maximum allowed value for new buildings.

Calculated energy needs reductions:

Heating energy needs reduction - 74.1%
Cooling energy needs reduction - 13.7%
DHW energy needs reduction - 94.5%

RES contribution:

Solar thermal energy contribution: 4.2 MWh/year

Overview economic efficiency and costs:

Total retrofit cost: 143 260 €
Total energy operation costs after renovation: 2160 €/year

Existing window sills

Costs	EUR	EUR/m²
Craftsmen	135 260 €	751 €/m²
Consultants	8 000 €	44 €/m²
Total	143 260 €	796 €/m²

Building context

Overall improvements, experiences and lessons learned

Energy
Energy needs reduction for heating, cooling and DHW, compared to original state over 75%.
Energy Certification Scheme, label **A+** (less than 25% of the maximum calculated non-renewable primary energy consumption allowed for new buildings)

Indoor climate
Absence of drafts
Absence of condensation phenomena
Comfort all year round

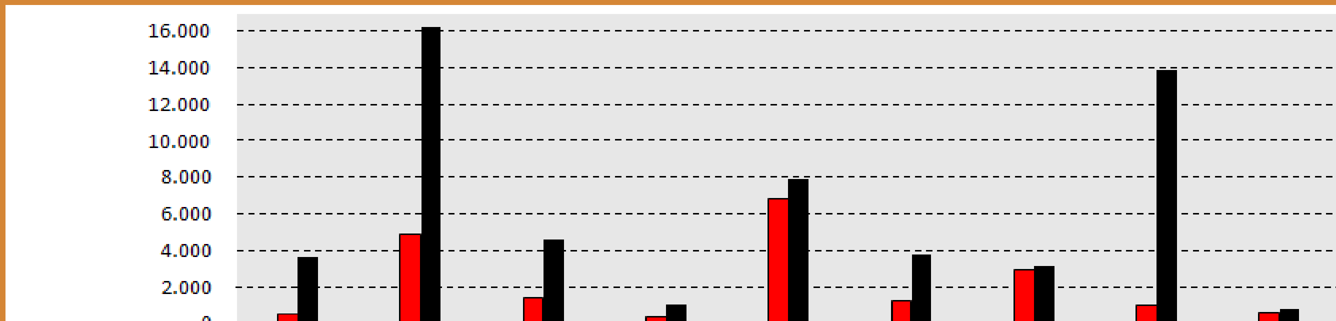
Economics
Renovations, especially those carefully driven by sustainable construction principles, as this one, is always good for the local economy. Now, tourists enjoying nature can be housed there and enjoy comfortable conditions with minimum environmental impact. Tourism economic benefits may also be used to pursue more retrofitting of regional traditional houses.

Decision process – barriers that were overcome
Barriers in this case were essentially related with the bureaucracy for obtaining the building permit and funding sources. The building permit from the municipality and national tourism entities is still a time consuming process that causes delays and doubts for the business plan. With respect to the investment costs, the building owners not always understood the unconventional nature of this renovation project, and therefore expected conventional costs as well, whether for the renovation works as for the consultants.

Non-energy benefits
Reuse of an abandoned traditional building, with preservation of its architectural value. Development, in an economically depressed region, of tourism activities with sustainability principles (optimal use of environmental resources; respect and interaction with the local community; long-term economic operations providing fairly distributed socio-economic benefits to all stakeholders).

Reducing embodied energy and environmental impacts through materials selection

Embodied CO_2 eq. amount for current and alternative material selection



Kg CO2 eq.	Windows and doors	Structure	Nonstructural suports	Paints and varnishes	Cladding	Plaster and mortar	Water proofing screens	Insulation	Bricks and Blocks
Current solution	3.631	16.233	4.588	1.049	7.953	3.815	3.177	13.917	859
Alternative solution	546	4.881	1.400	376	6.862	1.265	2.950	1.062	586

Summary

An existing traditional country house, located in Pontes village, in Castro Laboreiro, Melgaço, is being renovated from a ruined condition. Its non insulated and deteriorated present condition would lead to very high energy consumption, if occupied.

The present renovation project was elaborated aiming the architectural preservation, the low environmental impact and the offer of suitable comfort conditions for tourism exploitation.

Global energy consumption reduction can be as high as 94% when compared to the hypothetical use of the building at its present state, which could mean almost 6000€/year of potential savings.

The right kind of message is put forward to other possible regional initiatives as sustainability and nature protection are the core drivers of this project.

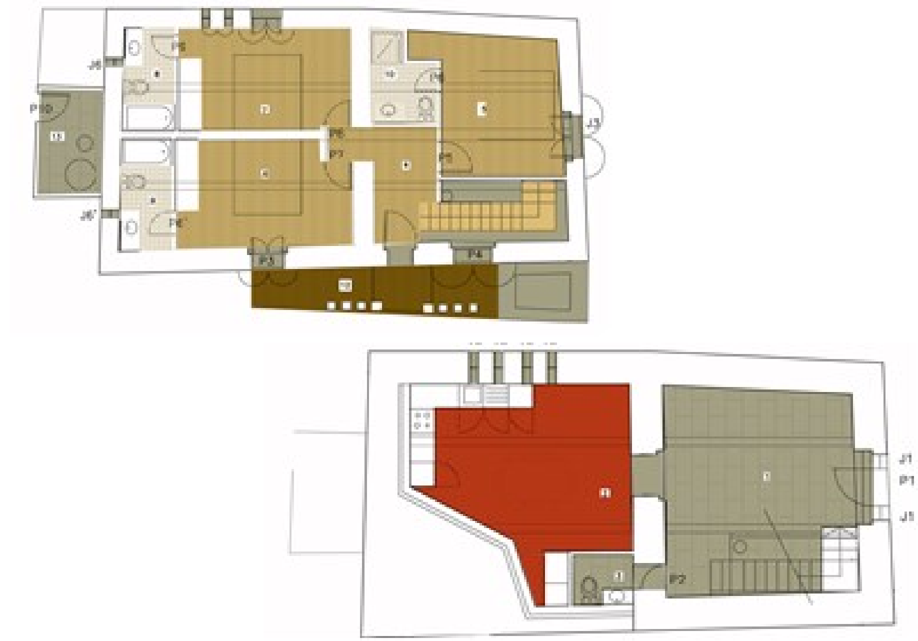
Acknowledgements

Inês Cabral – Architect and project coordinator. Deep knowledge of regional construction characteristics and sustainability in construction.

André Coelho – Civil engineer and energy in buildings specialist. Responsible for the thermal/energy analysis of the house, and its HVAC systems. Structural design and engineering disciplines coordination.

Gonçalo Machado – Architect, energy in buildings consultant and specification of materials specialist. Responsible for the materials environmental impact analysis.

Ecoperfil engineers, for this project – **André Batoréu** (water supply and waste water drainage), **Luís Rato** (electricity and telecommunications), **Rodrigo Castro** (acoustic design)



Lower and upper architecture plans of the retrofitted house.

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[1] – Cabral I., Coelho A., Gonçalo M., 2013. Assessing energetic self-sufficiency and low environmental impacts in protected areas with rehabilitation needs: Pontes Village case study. Proceedings of CIAV Conference 2013, Vila Nova de Cerveira

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Rainha Dona Leonor neighborhood, Porto, Portugal

Project summary

Energy concept

Although energy consumption were not the main concern in the engagement of the renovation process, a global intervention had to comply with current thermal regulation, thus providing a significant improvement in the energy performance of the building envelope, the installation of new heating/cooling and DHW systems and also the use of RES.

Background for renovation

This is a social neighborhood built in 1953 that reached a profound state of degradation. A deep renovation or demolition were the possible actions to take towards this neighborhood. The final decision was to renovate it and the approved project aimed to:

- Renovate the buildings that have reached a profound state of physical degradation
- Improve comfort conditions of dwellings that were built 60 years ago and were never upgraded
- Recover the neighborhood's image maintaining architectural and urban original characteristics
- Increase the dwellings area, adjusting it to todays people's life patterns
- Refresh of the neighborhoods surroundings taking advantage of its urban context

General view of selected building before renovation (left) and after the renovation (right)

Site: **Porto, Portugal**

Altitude 76 m

Heating degree days: 1610 (base temp. 20°C)

Owner: **Domus Social**

Architect: Inês Lobo Arquitectos, Lda.

Building description /typology

- Neighborhood with 150 dwelling that will be reduced to 90 after complete renovation
- Multifamily building, with concrete structure, brick walls and light weight slabs
- Originally built in 1953
- Gross heated area of the selected building: 123.60 m² (2 dwellings)
- Gross heated of the total renovated neighborhood: Approx.. 5000m²

Contact person: Domus Social, Porto

Important dates: Originally built in 1953
Renovation started in 2009
Renovation completed in 2014

Date of template Completed in 07-05-2014

Building envelope, heating, ventilation, cooling and lighting systems before the energy renovation

Description of building (building situation, building system, renovation needs, renovation options)

This neighborhood is a social housing complex with several two floors buildings with variations in the area and the number of bedrooms. It also has 3 apartment blocks, but the renovation intervention taking place includes only the two floor multifamily buildings.

Building envelope

The building has a concrete structure with single brick walls. It did not had any insulation in the exterior wall, roof or floor. The roof is made of fiber cement sheets with a wooden structure and a lightweight ceiling slab. The windows frames were made of wood and the windows used to have a single glass with external plastic blinds. The box for the blinds was placed outside the wall.

Heating, ventilation, cooling and lighting systems before retrofit

There was not a heating or cooling system installed. Occasionally it was used an electric heater or portable fan coils, that each user has acquired. The domestic hot water was supplied by individual electric heaters with storage tank and the ventilation was made by natural means.

Rainha Dona Leonor neighbourhood urban context

Building before renovation

Element	U-value before renovation (W/m²°C)
Exterior walls	1.69 (first floor) 1.38 (ground floor)
Window	3.40 (with external blinds)
Glass	Solar factor - 0.88
Roof	U value - 2.62 W/m^2°C

Energy renovation features

Energy saving concept

The main purpose of the intervention was to improve the livability of the dwellings and simultaneously restore consistency and homogeneity to the neighborhood by subtracting the illegally constructed elements, restoring the original volumes.

The main targets were:

- Renovate the buildings due to its deep degradation state
- Adapt the living areas to modern standards once the original dwellings were very small
- Improve the comfort inside the dwellings
- Renovate the outdoor areas such as playgrounds and circulation areas

Technologies:

- Exterior walls insulation
- Roof insulation
- Introduction of double glazing windows
- Day lighting improvement with bigger windows in the living room
- Efficient heating and cooling systems
- Solar thermal system for DHW

Building

- Wall: External insulation and wall renovation with 60mm of EPS covered by reinforced plaster;
- Roof: Insulation with 50mm XPS panels;
- Windows: Wooden frames + double glazing with 4mm and 6mm

Systems

- HVAC: Multi-split air conditioning system with a coefficient of performance (COP) of 4,1 for heating and energy efficiency ratio (EER) of 3,50 for cooling, on each flat.
- Lighting: Improved daylighting with larger windows.
- Renewables: 3m^2 of solar panels for DHW, per flat.
- DHW: New electric heater with storage tank

Element	U-value before renovation (W/m²°C)	U – value after renovation (W/m²K)	After renovation
Exterior walls	1.38/1.69	0.45/0.48	60mm EPS insulation
Window	3.40	2.90	Double glass and wood
Roof	2.62	0.64	50mm XPS insulation

Above and right: Buildings after renovation

Energy Savings, CO_2 reductions and Life Cycle Costs

	Before renovation (calculated)	After renovation (calculated)	Reduction
Heating Needs (kWh/m².a)	119.70	68.55	43%
Cooling Needs (kWh/m².a)	6.49	7.86	-21%
DHW Needs (kWh/m².a)	37.09	27.13	27%
Non renewable primary energy consumption for heating, cooling and DHW (kWh/m².a)	413.75	127.21	70%
Total annual energy consumption (kWh/a)	51 140	15 723	70%
Energy Cost for calculated life time of 30 years (€)	85 580	27 221	70%
Carbon Emissions (TONeqCO²/a)	18.92	6.02	70%

Costs	EUR	EUR/m²
Total Life Cycle Costs (NPV)	225 609€	1825€/m²
Total Investment	165 340€	1338€/m²
Investment in renewables	6 987€	57€/m²
Investment in systems	16 092€	130€/m²
Energy costs	27 221€	220€/m²
Maintenance costs	33 048€	267€/m²

Calculated energy savings:

Energy savings in each building (2 dwellings) due to the improvement of the envelop and control of infiltrations: 51.15 kWh/m².a
Solar thermal contribution: 9.96 kWh/m².a
Primary energy savings: 286.54 kWh/m².a
Total carbon emissions reduction:
12.9 ToneqCO_2.a

Global evaluation

"Within the municipality housing stock, Rainha Dona Leonor, by the deep renovation work that has been submitted, passed from Group I (very poor condition and / or low level of comfort) to Group V (good condition), becoming the best social neighbourhood of Porto, with comfort and liveability conditions superior to newly built neighbourhoods like Monte São João and Parceria e Antunes." *Rui Rio, Porto Mayor*

Building during the renovation process

Building after the renovation process

Overall improvements, experiences and lessons learned

Energy

Potential annual savings of 35417 kWh/a of primary energy in each building.

Indoor climate

Reduction of losses through walls, roof and windows;

Reduction of the thermal bridges allowing to eliminate related condensation problems;

Upgrade of the building energy performance. The standard energy performance for new buildings in Portugal has been achieved;

Control of indoor temperature and humidity without relevant energy costs.

Economics

These renovations were supported by the municipality, who owns and runs these neighborhoods allowing a significant increase of the rents.

Potential energy costs for heating, cooling and DHW have been reduced by almost 70%.

Decision process – barriers that were overcome

The lack of financing to carry out the works at once;

Strong discussion whether the best solution was to renovate or to demolish and transfer tenants to other buildings;

The need to have the buildings vacant to carry out the renovation works.

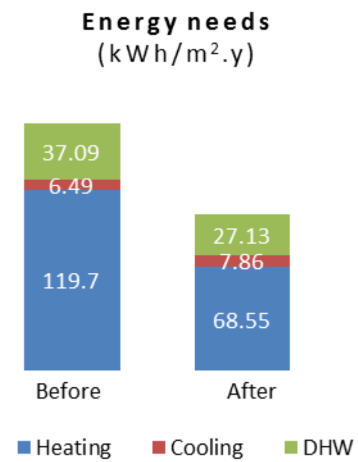
Non-energy benefits

Aesthetical improvement, returning the dignity and identity of the neighbourhood, reducing the social housing stigma;

Better living conditions with more space and more qualified living spaces;

Improved thermal comfort conditions with users now able to heat indoor spaces and keep the interior environment within healthy and comfortable temperatures;

Improved natural lighting with larger glazing areas in living room.



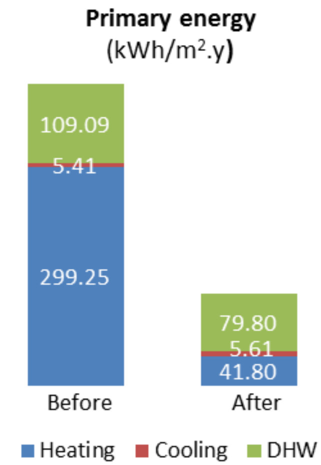
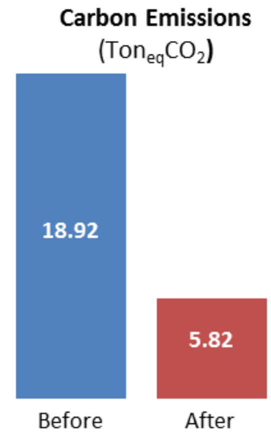


Figure above on the left shows the energy needs for heating, cooling and DHW before and after the renovation works calculated in accordance with the Portuguese thermal codes, which consider the comfort indoor temperatures of 20ºC in winter and 25ºC in summer.

Figure above on the right shows the non renewable primary energy use for heating, cooling and DHW, before and after the building renovation.

Figure on the right shows the carbon emissions before and after the building renovation related to the non renewable primary energy use.



General data

With this renovation process, the city hall achieved two main goals: return the confidence to the neighborhood and improve the living conditions of the local population.

Additionally, the potential reduction of the non renewable primary energy consumptions is about 70%.

The overall improvement of the neighborhood allowed to transform this neighborhood into the best social neighborhood of Porto city according to the evaluation of the municipality, with comfort and livability conditions much better than other recently built neighborhoods.

Front facade of the renovated buildings

Back facade of the renovated buildings

Acknowledgements

We want to offer our thanks to Domus Social, E.M. and Inês Lobo Arquitects, Lda. for sharing the data necessary for the development of the calculations and for the preparation of this shining example , and specially to José Ferreira from Domus Social, E.M. who kindly introduced us to the renovation process of this neighborhood.

Backa röd, Gothenburg, Sweden

Project summary

Energy concept: To achieve a substantial reduction of the energy losses

Background for the renovation – reasons

The technical status of the building was poor due to wear and tear and the energy use was high before the renovation. The intentions were to:

- Take care of the deteriorated façade
- Improve all technical systems, which were in bad condition
- Renew the kitchens and bathrooms, which were in bad condition (original condition)
- Renew the surface finish in the apartments, as it was needed
- Improve the energy efficiency

Before renovation.

After renovation.

Site: **Gothenburg**
Altitude: 35 m
Heating degree days: 3307 (base temp. + 17 C°)
Cooling Degree days: 0

Owner: Bostads AB Poseidon

Architect: Pyramiden Arkitekter

Engineer: Structural engineering: Byggtekniska Byrån i Göteborg
HVAC: Andersson & Hultmark

Building description /typology

- First 16 energy renovated apartments (of 1,564)
- Heated usable floor area 1,357 m²
- Built: 1971
- Prefabricated concrete elements and balanced ventilation without heat recovery

Contact person: Cathrine Gerle, project leader, Bostads AB Poseidon

Important dates: The first energy renovation was finished in 2009

Date of template completed: 2014-04-09

Building envelope, heating, ventilation, cooling and lighting systems before the energy renovation

Description of building (building situation, building system, renovation needs and renovation options).

Backa röd consists of 1,574 apartments in high-rise buildings, low-rise buildings and low tower blocks built during the million homes' program. The first building to be energy renovated, which is described here, is a low tower block with 16 apartments and 4 floors. The apartments have good floor plans, with generous and easily furnished rooms. However, the buildings needed to be renovated due to wear and tear.

Building envelope

The buildings are typical for the seventies with a prefabricated concrete structure of sandwich facades panels. The facades were damaged by carbonation and were in need of renovation.

The building was leaky, through the façade and between the apartments. Draught occurred from the in fill walls at the balcony and cold floor was caused by the thermal bridges from the balconies.

Heating, ventilation, cooling and lighting systems before retrofit

The buildings are heated by district heating. In each apartment there were radiators under the windows.

Domestic hot water is also heated by district heating. District heating is renewable to 81%.

The apartments were ventilated by mechanical exhaust and supply ventilation without heat recovery.

The intention of the renovation was upgrade the standard of the building.

Before renovation.

Element	U-value before renovation W/m²K	U-value after renovation W/m²K
Exterior walls	0.31	0.12
Roof	0.14	0.10
Ground floor	0.40	0.10
Windows average	2.40	0.90

Energy renovation features

Energy saving concept

The aim was to combine the necessary maintenance renovation with a 65 % reduction in energy use. The overall intention was therefore to:

- Renovate the building
- Reduce the energy use
- Improve the indoor climate

Building

- Additional insulation, loft and crawl space
- Exterior additional insulation and sealing of the façades and new windows
- The joints between the apartments were rendered impermeable to air movement with floating putty on the floor
- New draught-proofed curtain wall on the balcony side
- New balconies on freestanding supports to minimise thermal bridges
- Individual metering of and invoicing for hot water

Systems

Heating: New radiator system with thermostat valves. Temperature sensors in the apartments. Individual metering of domestic hot water.

Ventilation: Change from exhaust and supply system for ventilation to an exhaust and supply system with heat recovery (rotary heat exchanger), with an efficiency of 85%. Cooker hood with separate fan and no heat recovery.

Lighting: Low energy lighting for fixed lighting.

U-values, W/m²K	After renovation
Exterior walls	Adding 200 mm of thermal insulation
Roof	Total of 500 mm of thermal insulation
Crawl space	Additional insulation with 500 mm Leca and heat supply by supply air
Windows	Triple-glazed low energy windows

Renewable energy systems

None, apart from district heating produced to 81 % from renewable energy and the electricity is green electricity.

Other environmental design elements

Extended eaves and balcony after renovation

Achieved Energy Savings, CO_2 reductions and Life Cycle Costs

Energy consumption for heating, hot water and facility electricity before and after renovation:

Calculated energy consumption:		
before renovation:		178 kWh/(m²·year)
after renovation:		60 kWh/(m²·year)
calculated savings:		118 kWh/(m²·year)
Actual energy consumption measured over a 12 months period:		
before renovation:	normalized	178 kWh/(m²·year)
after renovation:	normalized	63 kWh/(m²·year)
actual savings:		115 kWh/(m²·year)
BBR2012 (building code requirement for new construction)		90 kWh/(m²·year)

As 81 % of the district heating is renewable energy and the use of electricity only increased somewhat the reduction in CO_2 emissions is small.

Calculated:
Energy savings thanks to reduced energy losses are calculated to be 147 MWh or 118 kWh/m². The measured energy reduction is 157 MWh or 115 kWh/m².

Renovation Costs and LCC(NPV)

Total (price level of 2009)	**18.05 mio SEK (2 mio Euro) of which 3.75 mio SEK (0.42 mio Euro) energy measures**	**14,500 SEK/m² (1,625 Euro/m²) of which 3,000 SEK/m² (335 Euro/m²) energy measures**
NPV (sum of discounted energy savings – investments, assumptions: cost of capital 4.25 %, calculation period 50 years, energy price increase 4 %/year). The owner has the tougher profitability requirement of 6.25 % and assumes that the energy price follows the inflation.	3.75 mio SEK (0.42 mio Euro)	3,000 SEK/m² (335 Euro/m²)

Overall improvements, experiences and lessons learned

Energy

Annual savings 147 MWh

Indoor climate

- Improved thermal comfort and indoor air quality

Economics

The costs have been divided into refurbishment 14.3 mio SEK and energy efficiency measures 3.75 mio SEK (total cost of 18.1 mio SEK).

The investments consist of standard-raising measures 6.0 mio SEK, operating cost reducing measures 1.8 mio SEK, neglected maintenance 8.3 mio SEK and unprofitable energy measures 1.95 mio SEK.

The payback time of the energy savings is estimated to be 25 years. However the owner only considers their yield (profitability) requirements.

Decision process – barriers that were overcome

The alternative of demolishing the buildings and building a new one was considered, but was not considered politically realistic as there is a severe lack of apartments in Göteborg. Besides it was a pilot project for energy renovation, to gain experience for future renovations.

Non-energy benefits

- Water and sewage systems replaced, hot water circulation installed
- New electrical installation
- New bathrooms and kitchens
- Change to parquet floor in living rooms and bedrooms
- New surface finish in the apartments
- Safety doors for the apartments
- New extended balconies, which also reduce the thermal bridges
- Façade repaired

Economic consequences for the tenants

Rent before: 694 SEK/m²/year íncl. space heating and dhw

Rent after: 938 SEK/m²/year incl. space heating

Rent increase: 244 SEK/m²/year

Energy savings: 160 MWh/year

Energy price (assumed): 1000 SEK/MWh

Savings: 160 x 1000=160,000 SEK = 118 SEK/m²/year

Users evaluation

The tenants perceive that

- Draughts from external walls and windows, and cold floors have been completely eliminated
- The room temperature is more comfortable, although it gets warm indoors in the summer.
- Unpleasant odors and noise levels have lessened

General data

Summary of project

The renovation was necessary due to wear and tear. The results were substantial improvements in the standard of the building and at the same a substantial reduction in energy use, 65 %, while keeping a similar exterior architectural appearance, however a completely different color. The energy saving measures had low profitability in this demonstration project. The standard improvements meant new installations, new bathrooms and kitchens, and new surface finish. The energy saving measures included added thermal insulation to the building envelope, low energy windows and installation of ventilation heat recovery.

The tenants have appreciated the improvements in thermal comfort, indoor air quality and noise climate.

After renovation with new facade and balconies etc.

Experiences/lessons learned

According to the owner the energy efficiency measures have not been profitable. Given the rather stringent yield requirements of the owner (profitability requirement of 6.25 %, energy price increase according to the inflation) only half of the energy investment will pay for itself.

If energy efficiency measures which result in improvements of indoor climate could be considered as standard-raising and allow a rent increase the profitability would be reasonable even with the stringent yield requirements. Major energy renovations only make sense in buildings which need a major traditional renovation. The profitability of renovations increases for bigger multi-family buildings and if many buildings can be renovated at the same time here.

The owner has therefore continued with similar energy renovations of five tower blocks of the same type in the same area. An additional feature is adding two floors on the roof. This way the profitability requirement of the owner will be met.

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[3] Mjörnell, K., et.al. 2011, Milparena – Million homes program arena Innovative action proposals for renovation of the building envelope and installations (in Swedish), SP Rapport 2011:39, Technical research institute of Sweden

Brogården

Project summary

Energy concept: Renovation using passive house technologies.

Background for the renovation – reasons

Intention for the renovation:

- Increase the accessibility
- Create a variation in apartment size
- Renovate because of wear and tear
- Improve on the poor thermal comfort
- Improve the poor energy efficiency by at least 50 %

Before renovation.

After renovation.

Site:	**Alingsås, Sweden**
Altitude	58 m
Heating degree days:	3724 (base temp. + 17 C°)
Cooling degree days:	0
Owner:	AB Alingsåshem
Architect:	Efem Arkitektkontor
Engineer:	Structural engineering: WSP HVAC: Andersson & Hultmark AB

Building description /typology

- Built 1971-73
- First 18 renovated apartments (of 300)
- Heated usable floor area (18 apartments) 1,274 m²
- Three storey buildings
- Poorly insulated building envelope and exhaust fan ventilation without heat recovery

Contact person: Ing-Marie Odegren, CEO, Alingsåshem

Important dates: Renovation of first 18 apartments finished in 2010

Date of template completed: December 18, 2013

Building envelope, heating, ventilation, cooling and lighting systems before the energy renovation

Description of building (building situation, building system, renovation needs and renovation options).

Brogården consists of 300 apartments in three-four storey buildings built during the million homes' program. The first building to be renovated, which is described here, has 18 apartments. The apartments have good floor plans, with generous and easily furnished rooms. However, the buildings needed to be renovated due to wear and tear, to increase the accessibility, to create a variation in apartment size and to improve the energy efficiency.

Building envelope

The buildings are typical for the seventies with a concrete structure and in fill wall. Walls consisted of gypsum boards on non loadbearing wooden studs, 95 mm insulation and façade bricks. Basement: cast-in-situ concrete walls were without any insulation. There was 300 mm insulation on roof slab and wooden rafters with props on roof slab. The windows were single pane with supplementary aluminum sash and one additional pane.

The apartments were perceived as drafty and had a poor indoor thermal comfort due to leaky facades. The balconies constituted thermal bridges. The façade bricks were partly destroyed by moisture.

Architecturally the wish was to preserve the impression of the façade e.g. the yellow brick façade.

Heating, ventilation, cooling and lighting systems before retrofit

The buildings are heated by district heating. In each apartment there were radiators under the windows. The radiators were regarded as worn out.

Domestic hot water is also heated by district heating. District heating is renewable to 98%.

The apartments were ventilated by mechanical exhaust ventilation without heat recovery.

The buildings needed a deep renovation.

Before renovation

Before renovation

Element	U-value before renovation W/m²K	U-value after renovation W/m²K
Exterior walls	0.30	0.11
Roof	0.22	0.13
Base plate	0.38	0.16
Windows average	2.00	0.85
Doors	2.70	0.75

Energy renovation features

Energy saving concept

The aim was to combine the necessary renovation with an upgrade to nearly passive house standard using passive house technologies.

Building

- Replacing the infill walls with well insulated new facades.
- Adding thermal insulation to the gables, the roof and the base plate.
- Improving the airtightness from 2 l/sm² to 0.2 l/sm² at 50 Pa.
- Replacing the windows with triple pane windows.
- Incorporating the balconies with the living rooms to eliminate thermal bridges and building new balconies supported by columns.
- Individual metering of household electricity.

Systems

Heating: Replacing the radiators with heating coils in the supply air of the ventilation system. Individual metering of domestic hot water.

Ventilation: Installation of decentralized balanced ventilation systems with heat recovery. The heat exchanger efficiency is 80 %.

Lighting: Low energy lighting for fixed lighting.

Element	After renovation
Exterior walls	Altogether 480 mm thermal insulation. Adding 430 mm of thermal insulation to the gables
Roof	Adding 400 mm of thermal insulation to the roof
Base plate	Adding 60 mm of EPS
Windows, average	Triple pane
Doors	New doors

Renewable energy systems

None, apart from district heating based on 98 % renewable energy .

Other environmental design elements

Added insulation to the foundation

Achieved energy savings, CO_2 reductions and life cycle costs

Energy consumption for heating, hot water and facility electricity before and after renovation:

Calculated energy consumption:		
before renovation:		175 kWh/(m²·year)
after renovation:		74 kWh/(m²·year)
calculated savings:		101 kWh/(m²·year)
Actual energy consumption measured over a 12 months period:		
before renovation:	normalized	175 kWh/(m²·year)
after renovation:	normalized	77 kWh/(m²·year)
actual savings:		98 kWh/(m²·year)
BBR2012 (building code requirement for new construction)		90 kWh/(m²·year)

As 98 % of the district heating is renewable energy the reduction in CO_2 emissions is small.

Calculated energy savings

Energy savings thanks to reduced transmission and ventilation losses are 129 MWh or 100 kWh/m²·year. Measured energy use is only slightly higher.

During reconstruction the building was covered by a tent.

Nice looking buildings with new balconies

Renovation Costs

Craftsmen	17.7 mio SEK	14,000 SEK/m²
Total of which energy measures	25 mio SEK (2.8 mio Euro) 7.1 mio SEK (0.8 mio Euro)	19,800 SEK/m² (2,225 Euro/m²) 5,600 SEK/m² (625 Euro/m²)
NPV (sum of discounted energy savings – investments, assumptions: cost of capital 4.25 %, calculation period 50 years, energy price increase 4 %/year) The owner applies the profitability requirement of 5.5 %, district energy price increase of 3 % and electricity increase of 5 % above inflation.	0 mio SEK	0 mio SEK

Overall improvements, experiences and lessons learned

Energy

Annual savings 100 kWh/m²·

Indoor climate

- Improved thermal comfort
- Improved indoor air quality

Economics

The client divided the costs:

1) Energy saving measures, will be paid back in 17 years.

2) Improved standard of the apartments paid for by the tenants (5 m² larger living rooms, renovated bathrooms etc.) with a 35 % average rent increase.

3) The maintenance cost for the buildings, in any case needed.

Decision process – barriers that were overcome

The planning process took long time partly due to poor project management, which was overcome by improved project management.

The preservation of the area and accessibility questions in the project took much time late in the planning process. The energy issues were almost neglected at least in the beginning of the project. Someone has to be in charge of the energy issue.

Non-energy benefits

- New balconies and larger living rooms
- Better indoor climate
- Increased accessibility (ground floor)
- New water/ sewage system, electrical installations, bathrooms and kitchens, surface finish inside.

Prefabricated facade elements for the next phase of renovation.

Economic consequences for the tenants

Rent before: 734 SEK/m²/year incl. space heating, DHW and household electricity

Rent after: 920-1120 SEK/m²/year incl. space heating

Rent increase: 186-386 SEK/m²/year

Energy savings: 127 MWh/year

Energy price (assumed): 1000 SEK/MWh

Energy savings: 100 SEK/m²/year

Users evaluation

The tenants were most satisfied with the new entrance, the entry phone and the fresh indoor air.

The tenants on the ground floor perceived occasionally the indoor temperature as low during the first winter and the users on the top floor perceived the indoor summer temperatures as high

General data

Summary of project

The renovation was necessary due to wear and tear. The results were substantial improvements in the standard of the building and at the same a substantial reduction (60 %) in energy use, while keeping a similar architectural appearance. This was done using traditional building materials and with common contractors. The energy savings were estimated to be paid back in 17 years. The planning process was very long in this demonstration project. The energy aspect was for a long time not considered important. The conclusion is that comprehensive efficient project management is needed and that energy has to be included from the beginning. All necessary competence has to be involved from the very start of a renovation project.

Long side façade with balconies before (left and above) and after (below) renovation.

Experiences/lessons learned

The most important lesson is that passive house technology for renovation requires that all competence work together from the start. The project has shown that it is possible to renovate a million programs' home to a very low energy use using traditional materials and common contractors. Besides it is an advantage to use standard material in standard sizes.

Central ventilation heat recovery on ventilation should be used instead decentralized, to reduce maintenance work and work changing filters. The façade construction should be simplified from a four layer on-site construction to a two layer construction with insulation, to reduce investment costs and simplify the production. For the following buildings (150 apartments) prefabricated façade elements are used for renovation.

The tenants were satisfied with the renovation.

Another important conclusion is that the tenants have to be informed from the beginning. In this project they had to move out during the renovation.

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Les Charpentiers

Project summary

Energy concept: Insulation, ventilation with heat recovery, passive solar facade

Background for the renovation – reasons

The goal is to renovate a building aged 45 years and to reduce the heating demand by 90 % (estimation before measurements). The energy related renovation measures are:

- Improvement of the facade and roof energy efficiency (insulation – windows)
- Reduction of ventilation heat losses by adding a mechanical ventilation with heat recovery. Each apartment has its own air handling unit (AHU)
- Use of innovative system for heating and domestic hot water distribution (instantaneous water heaters with heat exchanger)
- Improvement of lighting efficiency in common areas

Before renovation

After renovation

South and East facades

Site:	**Morges, Switzerland**
Altitude	373 m
Heating degree days:	2375 (12/20° C)
Cooling degree days:	-
Owner:	Caisse de pension COOP
Architect:	Patrick Hellmüller (Renovation)
Engineer:	Swissrenova

Building description /typology

- 5-storey with 61 / 59 flats (before / after)
- Year of construction: 1964-65
- GHFA: 4280 /4836 m2 (before / after)

Contact person: Mr Sergio Viva (Caisse de pension de la COOP)

Years of renovation: 2010 - 2012

Date of template Completed: November 2013

Building envelope, heating, ventilation, cooling and lighting systems before renovation

Description of the building and its situation before renovation (building situation, building system, renovation needs, renovation options)

The five-storey building is located in the city centre of Morges (Switzerland). The ground floor is a shopping centre and has not been renovated. The remaining storeys are composed of residential apartments. The four first floors were built in 1964-65. The last attic floor was added in the 80th. On the South and East facades there were balconies (covered during the renovation) and the total number of apartments was 61.

Building envelope

Exterior walls with almost no insulation. During 45 years, no renovation work has been performed, so the building needed a complete renovation of the apartments and of the building envelope.

Heating, ventilation, cooling and lighting systems before retrofit

The energy source was gas. The boiler and the DHW storage were located in a technical room. For each apartment, one water distribution system provides energy for heating and for DHW.

The flats were equipped with an exhaust ventilation from the bathroom and kitchen (simple exhaust ventilation).

No special lighting system was used and no cooling device was installed.

Living room before renovation

Kitchen before renovation

Element	Area, m² Before/ After	U-value before renovation W/(Km²)	U-value after renovation W/(Km²)
Facade	817.6 / 1235	0.36 – 3.06	0.13 - 0.34
Windows	1014 / 699	3.13	0.79
Roof (atic)	728.8 / 802.2	0.38 - 0.61	0.20
Roof (terrace)	150.7/ 296.5	1.28	0.13
Floor again exterior	32 / 168.5	1.18	0.15

Energy renovation features

Energy saving concept

- Pre-fabrication of passive solar facade (system gap-solution: www.gap-solution.at)
- A mechanical ventilation system with heat recovery has been installed in each apartment and an individual controller to allow tenants to reduce the electrical demand of the AHU
- Individual heat meter to make tenants more responsible of their heat consumption
- LED for common areas

Building

The renovation of the building thermal envelope was obtained by adding a pre-fabricated module on the existing facades and balconies. This solution increases by 14% the total heated gross floor area while the apartment size is increased by 22%. In addition, the heat losses through thermal bridges are dramatically reduced.

In each apartment, heat is distributed through a single system. In the bathroom, this heat is primarily used for the heating system (single radiator). If DHW is required, the heat is redirected to a heat exchanger to heat the domestic cold water (Swiss frame system).

The kitchen and bathroom facilities were completely renovated

Systems

Heating: Gas cogeneration (12 kW$_{th}$ and 5 kW$_{el}$)

Cooling: -

Ventilation: AHU with a heat recovery system

Lighting: LED (for common areas like corridors)

Renewable energy systems -

Element (only block A)	After renovation
Facade	Concrete 200 mm / Mineral wool 180 mm / GAP module
Windows	2-layer low-energy windows + 1 external glass with PVC frame
Roof (atic)	Mineral wool 160 mm / Mineral wool 300 mm
Roof (terrace)	Concrete 200 mm / Mineral wool 300 mm / Bitumen sheet 5 mm
Floor (above heating zone)	Plaster 50 mm / Mineral wool 20mm / Concrete

Pre-fabricated solar facade system from gap-solution

Achieved Energy Savings, CO_2 reductions and Life Cycle Costs

Energy consumption for heating before and after renovation:

Total gas consumption (heating)

Before renovation (mean value 2008 to 2009):	424 MWh/year
After renovation (First heating season 2011-2012):	43 MWh/year
Energy savings (heating):	381 MWh/year

Electricity consumption (corridor lightning, lift, laundry, pumps, ventilation):

Before renovation *	19.2 MWh/year
After renovation †	32.4 MWh/year
Energy savings:	-13.2 MWh/year

* No ventilation

† Ventilation with heat recovery

Energy savings:

The ratio of the heating demand before and after renovation is more than 10. Thus, the annual energy saving is around 380 MWh (117 tCO_2-eq).

The increase of electricity demand is mainly due to AHU added.

New prefabricated modules during the renovation

Renovation Costs and LCC (NPV)

Craftsmen	**8.4 million CHF**	**1737 CHF/m²**
Consultants	0.8 million CHF	165 CHF/m2
Total	9.2 million CHF	1902 CHF/m2
NPV	21 Years	5%

Renovated facade

Overall improvements, experience and lessons learned

Energy

Annual savings: 381 MWh,
79 kWh/m^2

Heating demand reduction: ≈90%

Indoor climate

- Better external noise insulation
- Improved IAQ (No discomfort about ventilation noise)
- Improved thermal comfort during the heating season
- No thermal discomfort during summer

Economics

In terms of investment cost, about 40% are due to improvements of the thermal building efficiency. The remaining amount concerns the replacement of the sanitary facilities, kitchen, lift and the change in the configuration of the apartments.

Rents have increased (+ 16%/m^2) but remain within current market value.

Decision process – barriers that were overcome

The challenge was to perform the renovation keeping the largest possible number of tenants. Some tenants have been moved several times.

Non-energy benefits

- Better comfort (noise, thermal)
- New apartment, new sanitary and kitchen facilities
- Larger living floor area

Economic consequences for the tenants

Rent before: 205 CHF/m$^{2/}$year

Rent after: 245 CHF/m^2/year

Increase: **40 CHF/m^2/year**

Energy savings: 381 MWh/year

Energy price: 80 CHF/MWh

Savings: 381 x 80=30.480 CHF = **8 CHF/m^2/year**

Indoor climate

Practical experiences of interest for a broader audience:

The tenants are satisfied with the improved of facilities, kitchen, bathroom and the refurbish of the apartments.

There are no more balconies but on the other hand they were used only as a storage place.

The fan speed of AHU could be selected by each tenant to fit the desired comfort.

Improved sound insulation is so good that the inhabitants have become accustomed to silence.

Users evaluation

A survey of occupant satisfaction has been sent to all tenants. Regarding thermal comfort, results are as follows:

- 76% comfortable to very comfortable
- 21% moderately comfortable
- 3% uncomfortable

Kitchen after renovation

General data

Summary of project
Different aspects were analysed and measured:

- U-value of the renovated facade
- Energy consumption for heating and domestic hot water production
- Thermal comfort during several representative periods
- Efficiency of the ventilation heat recovery
- Ventilation's noise distribution in apartments
- Air quality (CO2 and VOC)
- General feeling and behaviour of tenants (opinion survey)

The combination of the thermal envelope renovation and the addition of the individual ventilation system has led to a reduction by a factor of 10 in the energy consumption while providing an excellent comfort.

Aerial view of the building

Experiences/lessons learned

This project was able to show:

- Only one radiator per apartment can be considered
- Reductions by a factor of 10 in the heating energy demand can be achieved
- For the building owner, it is essential to renovate with tenants into the building in order to keep as many as possible. Thus, a great attention is given to communication with tenants and management of successive removals. After renovation, half of the initial number of tenants remained in the apartments.
- The role of caretaker is important for inform tenants regarding the use of the ventilation system and the concept of low consumption building. It is always possible to open the windows contrary to popular belief.

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Next Steps

This brochure reflects some renovation examples that are useful as depictions of built realities that, in a way or another, approach the topics under analysis in the scope of Annex 56. This small illustration of "Shinning Examples" demonstrates that a "one size fits all" approach is unviable in the diversity of contexts where a "Cost Effective Energy and Carbon Emissions Optimization in Building Renovation" is needed. Case by case these examples show that the implemented RUE / RES measures were a consequence of local opportunities and constraints, ownership and local laws, and not only a design option.

The shining examples documented so far may be characterised as forerunners initiated by "first movers" and therefore the experiences documented may be somewhat different from what other new renovation project may meet.

However, the multidisciplinary design approach of these examples demonstrates the potential of the renovation measures beyond functionality and energy consumption reduction. As a whole they state that this potential can be harnessed in all the scope of existing buildings renovations, from single family to multi-family buildings, with the appropriate adaptations to each context.

The aim, and current efforts, of the EBC Annex 56 on "Cost Effective Energy and Carbon Emissions Optimization in Building Renovation" is to provide designers with the tools to narrow the possible solutions - there are several alternatives and options are interrelated — for each building specific context.

The gathering of shining examples continues through the whole lifetime of Annex 56 and all examples will be presented in a final report at the end of the project.

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