Old Urban Building, Bilbao, Spain

Typology	Before: Residential + Commercial After: Residential
Total floor area	Before: 870 m^2 After: 730 m^2
Responsible partners	Surbisa Labein Eptisa-Cinsa

Summary

The Bilbao project, to be finished in 2007, is focussed on the possibilities to introduce sustainable solutions in renovations of old, historical buildings.
The energy savings potential in Spanish Demohouse building comparing to standard renovation turns out to be really huge, since traditional practices are very simple (e.g. poor insulation) and energy saving awareness is still incipient in buildings renovation. This results in economically interesting pay back times. On the other hand, unexpected delays in such a project should be taken into account.
The Bilbao project proves that renovation of buildings is a very relevant field where the decrease of greenhouse emissions has a great potential.

The building in its original state

The project, the challenges

This project aims at demonstrating that sustainable solutions can be introduced in renovation of very old historical buildings with acceptable payback periods of extra costs, and also being a good practice model for other similar buildings in the area (and the city as well) that will be renovated.

Context

The building is located in one of the historical quarters of the city of Bilbao, Bilbao La Vieja. This district has been for the last decades a degraded area with important problems of delinquency (drug traffic, prostitution, illegal immigration, etc.). However, Bilbao La Vieja is currently under a redevelopment process launched by the local authorities, which involves a renovation of old infrastructures, a more socially balanced environment and a socio-economic dynamisation of the quarter (e.g. supporting young people with social housing).

In this framework, one of the main goals of the demonstration activity is future transferability and repeatability in other buildings of the area, which involves a large number of potential housing renovations. Currently energy efficient renovation activities is strongly being encouraged by public bodies; and Demohouse project building is intended to be used as a good model/example for replication by private companies working in this field.

BUILDING CONSTRUCTION

The building has been renovated due to very weak structural conditions which could not ensure safety conditions. Although some actions were carried out during the 60's, no significant changes were included, and most of the features of the building have remained since the construction in 1910. The age and low maintenance conditions along the years of the building involve very poor conditions before renovation: single pane windows, no insulated walls, many uncontrolled air leakages,....

Although framework and main façades have been preserved, all other issues have had to be redesigned, including internal layout of the dwellings, roof, final use of the spaces, insulation and heating equipment.

The building in its original state

Solutions

BUILDING CONSTRUCTION

One of the main measures to be carried out has been thermal improvement of the envelope, including:

- External wall insulation. Although 5 cm of mineral wool was initially planned as insulation, research activities have allowed identifying aspects with best cost-effective response. As a consequence, insulation thickness of façades, roofs and basement has been increased by 5 cm compared to the original plans (considering other parallel aspects such as dwelling space, framework loads, etc.), assuming that the extra costs will benefit in the long-term.
  Thermal bridging problems have also been addressed.
- Windows. Low-e 6/12/6 double pane windows will be installed in the buildings, which can be considered as best available product in Spanish market.
- Air tightness has been addressed, installing one-piece roller blind boxes connected to window in order to avoid unexpected air leakages. This is a usual heat loss problem in Spanish buildings construction.

The building in its original state

HEATING SYSTEM

Originally a central heating system with radiators for the whole building was planned, but it was changed into a floor heating system (based on central condensing boiler) in order to improve users' satisfaction in terms of thermal comfort.

PV MODULES & SOLAR THERMAL PANELS

Renewable energy has also been integrated in the building: solar collectors are planned to assist domestic hot water production and also a 5.7 kWp photovoltaic system to produce electricity (sold to the grid). The preparatory studies for renewables have considered not only the technical aspects (area, orientation, slope, etc.), but also a balanced calculation including socio-economic aspects of the investment. According to these calculations (optimisation of the ratio thermal/electrical systems), 50% of domestic hot water can be achieved through thermal equipment and an electricity production of 4,545 kWh/year is estimated for the PV modules.

LIGHTING

High efficiency lamps will be installed in the building. Within the dwellings, dimming controls have been designed for automated blinds operation aiming a balance between thermal comfort (energy gains by solar radiation) and visual comfort (daylight control). Lighting in common areas of the buildings will be activated by presence sensors, minimizing the operation time.

Energy data

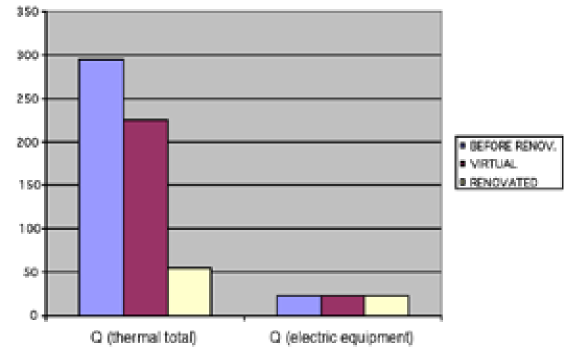
Three scenarios have been considered for energy saving calculation:

- Building before renovation: very poor constructive quality.
- Virtual Building: Renovation according to standard practice in building renovation.
- Actual Renovation: Renovation according to sustainable measures defined within Demohouse project.

Energy			
Cortes 34:	Before renov.	Standard renov.	Renovated
	Gross energy demand (kWh/m^2 year)		
Q (heating)	245	175	55
Q (hot water)	49	49	25
Q (lighting)	19	19	18
Q (equipment)	4	4	4
Q (thermal total)	295	224	55
Q (electric equipment)	23	23	22
TOTAL	317	247	77
REDUCTION		22%	76%

It is clear that the initial situation is highly energy wasting with huge energy demands. Standard renovation provides a significant improvement of about 22% energy savings. However, actual renovation will improve the energy performance around 75% out of the original situation and 68% out of the standard renovation.

These energy consumptions can be translated into CO_2 emissions according to emissions associated to natural gas combustion and according to energy mix of the electricity consumed in Basque Country. The CO_2 emission reduction is also significant and it is proved that renovation of buildings is a very relevant field where the decrease of greenhouse emissions has a great potential (1.13 Tons CO_2 /year in the demonstration building).



Economy

Energy savings can be translated not only into environmental benefits but also in economical terms. By means of a simple economical analysis following results can be obtained.

CO_2 Emissions			
Cortes 34:	Before renov.	Standard renov.	Renovated
	Emissions CO_2 (kg/m^2 year)		
Q (heating)	47	34	11
Q (hot water)	10	10	5
Q (lighting)	4	4	3
Q (equipment)	1	1	1
Q (thermal total)	57	43	15
Q (electric equipment)	4	4	4
TOTAL	61	48	20
REDUCTION		22%	68%

This is based on the following energy costs:

Heating: 0,045 €/kWh

Electricity: 0,100 €/kWh

According to the results it is clear that relevant economical savings can be achieved through the improvement of the energy performance of the building. This should be another important incentive to encourage these renovation actions. Estimated money savings in operation costs for the Demohouse building will be higher than 50% out of the standard renovation (virtual building).

These results do not include electricity production generated by photovoltaic modules of the roof, which are estimated around 2,500 €/year (based on current national law on renewable energy production). Considering this figure, a payback time rate of approximately 25 years is estimated (total savings: 5,900 €/year).

Costs			
Cortes 34:	Before renov.	Standard renov.	Renovated
	Operation costs per dwelling (€/year)		
Q (heating)	449	321	101
Q (hot water)	91	91	45
Q (lighting)	74	75	71
Q (equipment)	16	16	16
Q (thermal total)	540	411	146
Q (electric equipment)	90	91	87
TOTAL	630	503	233
REDUCTION		20%	63%

Insulation

First hand experiences

- Energy savings potential in Spanish Demohouse building comparing to standard renovation is really huge, since traditional practices are very simple (e.g. poor insulation) and energy saving awareness is still incipient in buildings renovation.
- Unexpected problems in the reinforcement of old buildings can cause delays in the renovation programme. Exploratory studies should be carried out in order to prevent difficulties (although not always is enough, as in Demohouse building, where despite the preparatory studies many problems in the foundations have arisen).
- The promising preliminary calculations on energy savings and the direct transferability/repeatability to many potential building renovations show a very hopeful scenario for housing renovation in Bilbao (and even in the Basque Country and/or Spain).

Total eligible costs	
	Euros
Building	228,700
Design	70,000
Monitoring	55,000
Reporting	47,000
TOTAL	460,700

Roof construction

Solanova Building, Budapest, Hungary

Typology	Before: military building After: residential building, social housing
Total floor area	2,100 m^2 , 3 storeys
Responsible project partners	EMI, Non-profit Company for Quality Control and Innovation in Building

Summary

This project has the potential to have a great impact on future renovation projects in Újpest and in Hungary. Especially as the only other Hungarian low-energy renovation, the SOLANOVA-building in Dunaújváros, is far from Budapest, has another building type and a totally different ownership system.

The project will draw the attention to solar renewable energy systems use (thermal collector and PV) and will point out that future social housing projects should focus on energy issues, not being the practice yet. The importance of quality control will also be emphasised.

Besides, as a result of the low operational cost, it will be a unique example for social housing for middle- and low-income people.

Photo and layout of the project area

The project, the challenges

The project aims at the retrofit of three empty military buildings by transforming them into social residential buildings. In the neighbourhood area a new housing block was established in 2006, the dwellings were sold and the new tenants/owners now live there.

Although research can provide very important data about the thermal behaviour of this building type and the possible measures savings, the main purpose of Demohouse is the demonstration, as low-energy renovation is still very rare in Hungary. An important drawback however, is that for this building type, there are no monitoring data available yet.

Due the cut of the central subsidy, the Local Authority of Újpest decided to apply for a Private Public Partnership scheme for the financing of the retrofit project. This will also be a solution to avoid the barriers of the changing subsidy systems. The project is the latest part of the design works. The works will start with the implementation of the PV-assisted ventilation and the construction of the prototype roof-top apartment and then will continue with the retrofit of the buildings.

The project building in its recent state

The project building in its recent state

Context

The project site is situated at the northern border of Budapest, in Újpest, close to the planned M0 outer ring motorway, the m^2 national highway and the Danube River. It is a former military area, where the buildings were mostly demolished, and a new canalisation-system has been established.

BUILDING CONSTRUCTION

The buildings, built in 1955–1960, have masonry walls without insulation and single glazed windows. Since the building has not been use for a while, they are in a bad condition. Most windows e.g. are broken. According to calculations, the energy consumption if inhabited in the current state would be above 200 kWh/m^2a.

Solutions

ROOF-TOP APARTMENTS

apartments. The roof will be built with high thermal resistance ($U = 0.2\ W/m^2K$). As the main axis of the roof is North and South, for the better orientation of the solar systems a flat roof area was planned between the two West-East oriented pitch roofs. An extension opportunity is planned. For natural ventilation and natural lighting integrated roof windows are planned.

BUILDING ENVELOPE

The internal walls will be demolished and new light-weight partition walls will be erected. The external walls and the size of the openings remain, but ETICS will be mounted on the walls. In the three buildings, thermal insulation of different thickness will be applied (6, 12 and 20 cm). Here lower heat conductance polystyrene will be implemented, achieving better thermal insulation in the same thickness. New low-e windows (U=1.2 W/m^{2}K) with external shading will be installed.

VENTILATION

After the retrofit, the air-tightness of the building is expected to improve significantly. An effective mechanical ventilation system is planned (with partial heat recovery), which is not a current practice in Hungary. It is planned to run the ventilation from a renewable power supply by installing PV-modules on the flat part of the roof. In the initial phase the produced electricity will be sold to the net, as green electricity yields higher prices. Later, when this benefit will be not the case, the electricity will be used to assist the ventilation.

In the first demo phase the PV-tower assisted heat recovery ventilation system will be installed and tested in the reference building in three flats. Here the efficiency, the relative humidity, the acoustic load and the user behaviour will be tested.

HEATING

In one of the buildings we will use a biomass wood chip burner and solar thermal collectors for heating and domestic hot water, which for Hungary is a new (integrated) system. The two other buildings will be equipped with gas burners, also assisted with thermal collectors. In the initial phase 1 m^2 collector surface/ dwelling is planned, but the system will have the opportunity of a later extension of 2.5 m^2 collector surface/ dwelling. The collectors will also be installed on the flat roof.

PROTOTYPE

For further testing and dissemination, a prototype of the (half) roof-top apartment will be installed in a central place of the district, with an aim of achieving a CO_2 neutral building with very low energy consumption, using a heat pump and PV modules.

3D model of the design options

WATER AND WASTE

Reuse of rain water and selective waste management system is foreseen.

MONITORING

The renovations and the demonstration activities will be assisted with quality control and monitoring. The air-tightness will be measured by blower-door tests after installing the new windows and finishing the whole building. The reduction of the effect of thermal bridges will be approved by thermography as well as leakage detection. The consumption and energy production values (gas, wooden chips, water, domestic hot water, electricity, green electricity, performance of solar collectors) will be monitored and registered for one year. The performance (air-flow, temperatures before and after the heat exchangers and acoustic parameters) of the heat recovery units will be measured, too.

Climatic data, such as outdoor temperature, humidity, solar irradiation and wind will also be registered by a weather station installed on the construction site. Finally, the comfort parameters will be monitored by movable data loggers positioned at representative points of the buildings. Most sensors will register air temperature, but some will measure relative humidity and light as well. Light is necessary to see how the shading devices are used.
The representative data pattern will enable statistic analysis to determine stochastic relations between parameters. This will improve the scientific value of the project.

IMPROVEMENT DUE TO DEMOHOUSE RESEARCH

As the thickness of the polystyrene thermal insulation could have negative influence on fire propagation, the increase of the U-value with the same thickness could be achieved applying a material with higher heat resistance. This innovative material will be applied during the renovation work.

As an outcome of the reference building evaluation the effective ventilation is very important due to the high air tightness of the building after the reconstruction. Quality control on renovation work with Blower Door Test and infrared photography allows the possibility of identifying the weak points.
The thermal collector system has good efficiency in the reference project. An opportunity for later extension of the originally planned thermal solar collector system is integrated in the design.

3D model of the design options

Residential Buildings, Attica, Greece

Typology	4 residential buildings, each building consists of three detached dwellings, maisonette type
Total floor area	approx. 900 m^2 each maisonette
Responsible project partners	THEACY S.A. (www.designervillage.gr) Group of Building Environmental Studies, National & Kapodestrian University of Athens (NKUA), (www.uoa.gr/, http://grbes.phys.uoa.gr)
Architects	Building 1 G+E Maneta. Buildings 2,3: D. Rizos Building 4: D. Agiostratitis

Summary

The Greek DEMOHOUSE buildings are a good example of healthy, cost effective and energy efficient dwellings. Their design aims at the implementation of sustainable solutions and the use of renewable energy sources and building energy management systems.

They are characterized by excellent indoor air quality and very low energy consumption compared to the common practice in Greece that is characterized by poor levels of insulation and not effective systems of cooling and heating. The estimated energy savings for the Greek DEMOHOUSE buildings are significant in the area of heating, cooling and ventilation.

The project, the challenges

This project aims at implementing low energy and sustainable measures in new to build dwellings, in compliance with the needs of the Greek market and the climatic characteristics of the area; also considering solutions with reasonable payback periods.

Context

The buildings are developed in a private area of 130 acres, on the foothill of mountain Dionysos, north of Athens. The site is suburban and has easy access to the center of Athens, to the surrounding suburban areas and to the beach of N. Makri and Sxinias. It is very close to the facilities of Ekali and Kifisia area (pharmacy, mall, clinics etc) and the national highway of Athens-Lamia. Also, the site has easy access to the airport. Greece participates in the DEMOHOUSE project with a new housing complex. Four buildings (maisonette type) are under construction: The maisonettes consist of 3 detached houses of similar design and are intended to house a 4-6 member family each. The maisonette has three levels and a total floor area of approx. 900m^2 with store rooms in the basement, living, dining area and kitchen in the ground floor, and bedrooms in the first floor.

Building 1

BUILDING CONSTRUCTION

The Greek DEMOHOUSE project is a new to build housing complex. The construction of the dwellings follows the typical practice in Greece: reinforced concrete baring structure, brick–cavity-brick for the external walls and steel roof structure with tile cladding but with increased insulation levels compared to the existing building regulations. Double low e glazing with thermal break is used for the windows.

Solutions

BUILDING CONSTRUCTION

The intention was to provide a very well insulated building envelope with increased insulation to the external walls and roof and better insulated windows compared to the existing building regulations (thermal insulation code 1981).

The construction of the dwellings follows the typical Greek approach but with extra insulation compared to the existing building regulations: increased width of insulation is used to the external walls and roof.

The use of double glazing and aluminium frame without a thermal spacer is the common practice in Greece. In the DEMOHOUSE dwellings double low e-glazing with argon and thermal breaks are installed for better insulation.

This results in a significant decrease of the heat losses from the building envelope by decreasing the mean U-value of the skin. Additionally, studies through simulations have been carried out to optimize the openings for optimum ventilation, thermal and visual comfort. All openings placed in the south façades of the building contribute to passively heat the living spaces. In order to minimize the solar gains during summer, fixed and movable shading is placed in all the openings of south, east and west orientation.

PASSIVE COOLING

To reduce reliance on active air conditioning and to provide thermal comfort during the summer period, earth air exchangers are installed in the dwellings. The installed exchangers have an approximate length of 35m and 25cm diameter. The proposed installation depth is 2.5m from the ground surface.

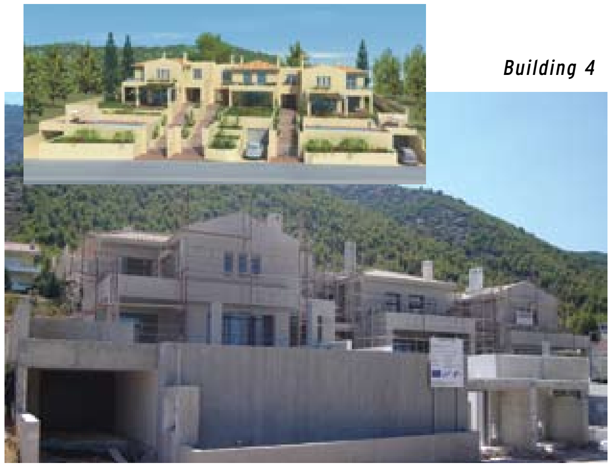
Building 2 & 3

Additionally, the dwellings are designed with appropriate height for the installation of ceiling fans in selected areas. The selection of the areas will be decided according to the occupants needs. The usage of the ceiling fans increases the thermal comfort temperature up to 1.5 °C and reduces the need of air-conditioning.

The overall design of the building allows achieving up to 10 air changes per hour during the night period. Night ventilation will be achieved through openable windows by the occupants. Moreover, the design of the overall ventilation system aims to improve the air quality and to decrease the heating and cooling loads of the building by using demand control ventilation and heat recovery. A demand control ventilation unit will be installed in each building. The system will be connected with the Building Energy Management System (BEMS) and will be controlled by it. In selected locations of each dwelling CO_2 sensors will be placed. When CO_2 concentration exceeds the permitted levels, the BEMS will start to operate the fans of the zone and extra fresh air will be supplied into the space. Thus the quality of the air will be always maintained inside the requested levels with reduced ventilation energy for heating.

LIGHTING

The dwellings are ventilated by natural ventilation High efficiency fluorescent lamps are suggested to be used in the interior of the building. Additionally daylight compensation techniques will be used in order to make the best possible use of daylight. For further energy reduction due to lighting, the lighting levels in the living rooms will be controlled by the BEMS of each dwelling according to the daylight.



Building 4

VENTILATION

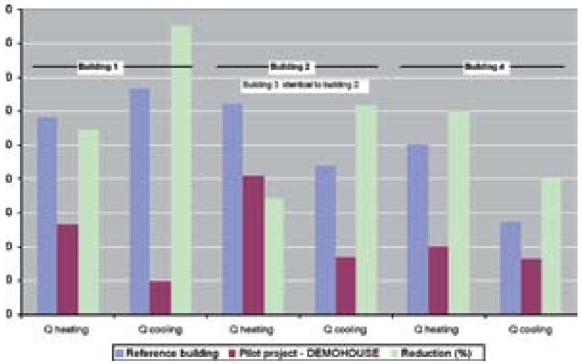
The dwellings are ventilated by natural ventilation through openable windows. The design permits the use of cross flow and single sided configurations.

BEMS & MONITORING

A Building Energy Management System (BEMS) will be installed in each dwelling to control the building systems. This will ensure the optimal operation of the systems. Also the BEMS will measure and calculate in real time the specific performance of all the used techniques. More specifically, the BEMS will control the operation of the earth-air exchangers, the operation of the movable shading systems with regard to the daylight levels and the operation of the demand control ventilation. Additionally the BEMS of each dwelling will record the energy consumption for heating and cooling, also will monitor internal temperatures in all areas, external temperature, CO_2 concentration, and lighting levels in the living rooms.lighting levels in the living rooms will be controlled by the BEMS of each dwelling according to the daylight.

Energy data

In order to achieve low energy consumption, the proposed techniques deal with the building envelope, the ventilation systems, the use of passive heating and cooling systems and the use of management systems. Therefore the reduction in energy consumption is attributed mainly to the heating and cooling systems as follows:



Energy demand	Reference model (virtual building - standard renovation)	Pilot project - DEMOHOUSE dwellings	Reduction (%) compared to reference model
Building 1			
Q (heating)	58.04	26.40	54.5
Q (cooling)	66.83	9.96	85.1
Building 2 & 3 (identical)			
Q (heating)	62.32	40.89	34.4
Q (cooling)	43.93	16.90	61.5
Building 4			
Q (heating)	49.98	19.88	60
Q (cooling)	27.34	16.43	39.8

ESTIMATED SAVINGS

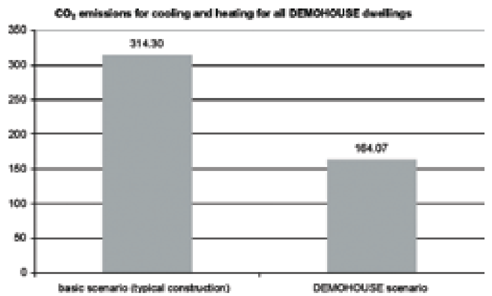
Energy saving measures heating, cooling, ventilation Building 1		
	kWh/m² year	Reduction compared to reference model (%)
Heating		
Improved insulation of external walls and roof	7.5	12.9
Low e windows with argon	1.5	2.5
Cooling		
Shading	0.79	1.2
Use of night ventilation	12.52	18.7
Earth air heat exchangers	44.14	66
Use of ceiling fans	7.24	10.8

Energy saving measures heating, cooling, ventilation Building 2 - Building 3		
	kWh/m² year	Reduction compared to reference model (%)
Heating		
Improved insulation of external walls and roof	18.36	29.4
Low e windows with argon	1.2	2
Cooling		
Shading	26.8	42.9
Use of night ventilation	8.26	18.8
Earth air heat exchangers	24.32	56
Use of ceiling fans	6.68	15.2

Energy saving measures heating, cooling, ventilation Building 4		
	kWh/m² year	Reduction compared to reference model (%)
Heating		
Improved insulation of external walls and roof	15.42	31
Low e windows with argon	1.51	3
Cooling		
Shading	3.19	11.6
Use of night ventilation	4.9	17.8
Earth air heat exchangers	8.63	31.6
Use of ceiling fans	6.89	25.2

The simulation results show significant reductions in heating and cooling loads between the reference model and the pilot project. According to the dwelling's design and taking into account all the proposed energy techniques, for the four different maisonettes the energy savings for heating are calculated to 54.5%, 34%, 34% and 60% respectively. The energy savings for cooling are calculated to 85%, 61%, 61% and 40% respectively.
Specifically, based on the simulation results, the energy savings due to the improved insulation vary from 13-31%. The reduction in cooling loads due the use of the earth heat exchangers ranges from 31-66%, whereas the reduction of cooling loads that is attributed to the use of ceiling fans ranges from 11%-25%.

Taking into account all the proposed energy improvements the calculations show a 48% reduction in CO_2 emissions for the four dwellings (graph below) compared with the corresponding emissions of the common practice in Greece where conventional air conditioning would be used. The CO_2 emissions are calculated for heating and cooling.



ECONOMY

A simple payback analysis (cost/benefit analysis) was carried out for the pilot projects taking into account all the energy measures. The payback time is calculated to 3 years excluding the installation of the BEMS and to 6 years including the installation of the BEMS. The BEMS is considered to be the most expensive energy measure depending a lot on its manufacture.

In general, the analysis results in short payback period. The necessity of the BEMS system to manage and operate the different functions, to record the energy performance of the building and to detect any possible malfunctions can justify the extra cost for the system and the higher payback time.

Scenario - All Buildings	Costs, operation heating (€)*	Costs, operation electricity (€)*	Costs, operation total (€)*	Costs, invest-ment (€)*	Payback time (years)
Model according to build regulations - reference building	15,258	30,499	45,757	-	-
Renovation - pilot project excluding BEMS	5,252	12,522	17,774	210,326	10
Renovation - pilot project including BEMS	7,879	12,379	20,258	426,326	11

*) Based on the following energy costs:
Heating (oil): 0,06 €/kWh
Electricity for cooling: 0,119 €/kWh

The payback analysis is carried using a simple calculation method based on cost estimates, (on the extra costs and the current cost for heating and electricity) and energy savings.

First hand experiences

- The 'DEMOHOUSE' dwellings can be an example of how passive design, energy efficiency measures and building energy management systems can be used in the design in order to provide low energy buildings. Usually these parameters are not considered in the traditional design process in Greece where there is no goal to minimise energy use and costs beyond the building regulations.
- The 'DEMOHOUSE' project in Greece can be considered a good example of the ground cooling use as a passive cooling method in the southern patterns of Europe where the climatic characteristics impose high cooling loads and extensive use of domestic air-conditioning. This technique can be combined with the use of complementary methods of hybrid cooling to enhance occupant comfort while reducing energy consumption, like ceiling fans and demand control ventilation.

Gyldensparken Housing Blocks, Copenhagen, Denmark

Typology	Housing blocks
Useful floor area	43,410 m^2
Promoter	Cenergia Energy Consultants
Participants	Kuben Urban Renewal

The project, the challenges

The central questions in this project are: is it possible to adapt older housing blocks to actual energy consumption levels and what wil be the payback time compared to renovation without extra energy saving measures.

Summary

This project proves that taking energy saving measures considerably shortens the payback time of a renovation project. In this case it turned out to be possible to bring back the energy consumption level of the Gyldenrisparken blocks with 500 appartments, built in 1965 – 1969, to actual energy levels. The payback time is going to be 7.3 to 10 years, which compares very favourably with renovation without extra energy saving measures: 35 years.

Gyldensparken in bird's view

Context

The housing blocks Gyldenrisparken include 500 apartments divided between several blocks of flats. The with a total built up area of 43,410 m^2. The heat for the housing blocks is supplied by district heating and the consumption of heat is considerably higher than one would expect in new modern apartments. The housing blocks are built as a concrete panel assembly construction in 1965-69 and just now the buildings are about to be thoroughly renovated. A standard renovation of the housing blocks will be carried out and for 96 apartments in for example 3 of the housing blocks where it is the idea to implement different levels of special energy-saving measures. One block or one area of 1/3 size of the total will be renovated using an energy-saving level of 50%, level B, and one area also with 1/3 size at level A with 75% savings and finally the rest of the area with 85% savings at level A + Solar. The savings are related to the present situation.

The three renovation projects with energy-savings will be carried out as stage one, thus the experiences obtained here can be used for the blocks/apartments to follow.
In the following we look at 3 housing blocks with 96 apartments in all as an example of how the project can be realised: The chosen blocks in the following are similar as to size and design. Each block holds 32 apartments with a total heated living floor space of 2,880 m^2.

DATA FOR ONE BLOCK

Windows	432	m^2
Façades (net area)	1,296	m^2
Gables	240	m^2
Heated area	2,880	m^2
Building volume	8,640	m^2

Solutions

STANDARD RENOVATION

Apart from the usual building improvements a standard renovation of the Gyldenrisparken contains 100 mm insulation of the external surfaces, new windows with standard specifications, new heating distribution system and simple water saving measures.

EU-PROJECT LEVEL B

In addition to the standard renovation the EU-project level B contain a requirement controlled PV assisted air exhaust with effective DC fans from EcoVent, insulation of the roof, use of Building Energy Management System (BEMS), low-energy windows as well as more comprehensive water saving measures.

EU-PROJECT LEVEL A

In addition to the cost-saving suggestions in level B the EU-project level A will contain ventilation with heat recovery with low electricity use from EcoVent, super low-energy windows with U-value of 0.85W/m^2K and include an increased effort regarding air tightness of the apartments. The idea is here to optimise the total design in relation to the "Houses without heating system" concept in co-operation with the partners from Sweden, and in cooperation with the EcoVent company who was also involved in the realisation of the CO_2 neutral test house which is being exhibited in the municipality of Copenhagen.

ENERGETIC AND ADDITIONAL RESULTS
EU-PROJECT LEVEL A + SOLAR

Yearly consumption	present situation	Std. Renovation	EU-project Level B	EU project Level A	EU project Level A + Solar
Space heating, kWh/m^2	130	72	57	19	19
Hot water heating, kWh/m^2	26	25	17	17	7
Total heating, kWh/m^2	156	97	74	36	26
Total water, m^2	2,880	2,736	2,160	2,160	2,160
Domestic hot water, m^2	950	903	713	713	713
Elektricity, kWh/m^2	12	12	8	8	4

addition to the cost-saving suggestions in level A the EU-project level A + solar will contain, 64 m^2 solar collectors as additional heat source for domestic hot water and 100 m^2 PV-modules.

Calculated yearly consumption of water, heat and electricity: The total yearly energy consumption of heat and domestic hot water is 156 kWh/m^2. By implementing a standard renovation the energy consumption for heat will be reduced to 97 kWh/m^2. If the special energy-saving "level B" is implemented an energy consumption of 74 kWh/m^2 is expected. By implementing further level A an energy consumption of 36 kWh/m^2 is expected equal to a reduction of 78% and finally is expected 83% savings for level A + solar.

A water saving reduction of 25% is expected. The commo electrical consumption will be reduced by 33% and 67%

respectively for the saving suggestions level B and A + Solar.

The environmental improvement can be calculated as a reduction in the yearly CO_2 emission from the heat and electricity consumption (heat: 0.2 kg/MWh and electricity: 0.6 kg/MWh).

Calculated yearly CO_2 emission per housing block from the heat and electricity consumption:

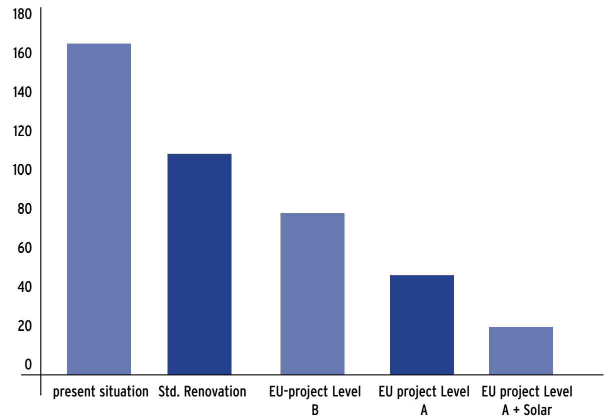
A reduction of the CO_2 emission will be obtained if the project is carried out – 52% for level B and as much as 80% for level A + Solar.

YEARLY SAVING OF ENERGY FOR HEATING

Heating	0.081 €/kWh
Water	3.57 Euro/m^3
Electricity	0.183 €/kWh

RUNNING COSTS

Expenses for the consumption are:



Various techniques including PV-assisted air exhaust and EcoVent

ECONOMIC VIABILITY

Budget per block (euro)	Std. PROJECT	EU-project Level B	EU project Level A	EU project Level A + Solar
Insulation of gable	16,107	0	0	0
Insulation of roof	67,651	0	0	0
Insulation of façade	139,168	0	0	0
DC fans	0	12,886	0	0
Ventilation with heat recovery	0	0	77,315	77,315
Heating system	128,859	0	-64,430	-64,430
Building Energy Management System (BEMS)	8,949	17,897	17,897	17,897
Windows	85,906	28,993	57,987	57,987
Water savings	6,443	12,886	12,886	12,886
Solar heating system	0	0	0	34,362
Photo voltaic	0	12,000	0	41,691
Air tightness	0	0	17,181	17,181
Sum	453,083	84,662	118,837	194,890
Design	45,308	8,719	14,260	24,827
TOTAL	498,391	93,382	133,097	219,717
Support 35%	0	32,683	46,584	76,902

TOTAL
446,196

The budget for the energy- and water related improvements in the project are as shown in the next table.
The standard project contains no eligible costs. The EU-project – level B contains total extra construction costs of € 93,382. Level A calls for an extra investment of € 133,097 and level A + solar € 219,717.

PAYBACK TIME

The economic viability is based on the extra costs in energy savings measures and savings in energy and water compared to a standard renovation. The calculated payback time is without EU support or other EU related costs.

Payback time	Std. Renovation	EU-project Level B	EU project Level A	EU project Level A + Solar
Total costs (euro)	498,391	93,382	133,097	219,717
Savings (euro)	14,228	9,659	18,329	22,474
Payback time (years)	35.0	9.5	7.3	10.0

TOTAL EU-PROJECT

Total eligible building and design costs	446,196
Prototype systems testing	55,000
Organisation work	48,000
Meetings	6,000
Monitoring / prototype and demo (besides RTD work)	28,804
Total eligible costs (96 flats)	584,000
EU support 35%	204,400
RTD activities by Urban Renewal Copenhagen (50% support)	36,000
TOTAL	620,000

green Quality Building Process will be aimed at in connection to the design process. Here it is the idea to present the local stake holders with a catalogue of best available technologies including performance requirements and check systems. The aim is to develop minimum standards for eco efficient renovation and give an input to certification systems for retrofit projects. In the future the costs for heating system in the budget can be reduced based on more experience and optimisation. This will probably lead to payback times of around 5 years for the level A example.

High-rise Multi-dwelling Houses, Graz, Austria

Typology	Before: Social Housing After: Social Housing
Total floor area	Before: 9,857 m² After: 9,857 m²
Responsible project partners	Landlord: ENW / Ennstal - Neue Heimat - Wohnbauhilfe Gemeinnützige Wohnungsgesellschaft m.b.H. Scientific: IFZ / Inter-University Research Centre for Technology, Work and Culture, Graz

Summary

Aim of this project is the optimisation of renovation measures to reduce energy and CO_2- emissions with pay back times applicable to the Styrian social housing system. The comparison between two renovation standards, a virtual renovation of the existing building based on the Styrian building standard from the year 2003, and a real renovation 30% better than this 2003 standard, will show the potentials of energy efficient renovation.

Situation before renovation - East façade

Situation before renovation - West façade

Context

The refurbishment projects of the Austrian housing company are two blocks of flats in the city of Graz: Laudongasse 14 and 16 as well as Starhemberggasse 13 and 15. Both buildings were constructed in 1976 and they consist of 127 flats (between 75 and 110 square meters each) in total. All flats are rented. Tenants comprise all age groups with some overrepresentation of the group of 50-60-year-old people. There is also a rising proportion of immigrants and asylum seekers living in the buildings. To secure a high acceptance of refurbishment measures, special emphasis will have to be put on communication between the housing company and tenants.

BUILDING CONSTRUCTION

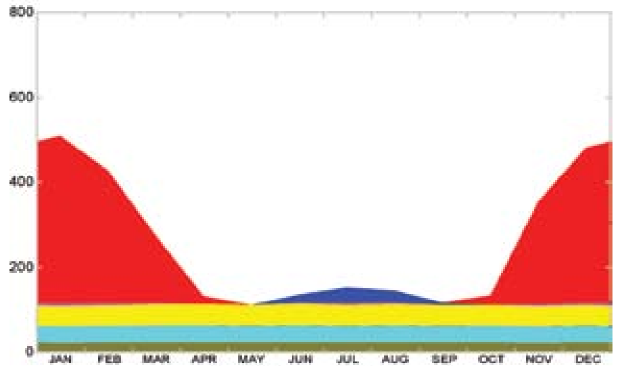
the outer walls are wood-fibre coated concrete and isolating plaster with a total thickness of 330 mm and an U-value of 1.42 W/m²K. The flat roof has an U-Value of 1.19 W/m²K and the existing windows are constructed as wooden windows with compound double glazing with an U-value of 2.30 W/m²K. Space heating and hot water supply are provided by the district heating net of the city of Graz. The yearly energy consumption of the existing building for space heating is 138 kWh/m² gross area.

Solutions

BUILDING CONSTRUCTION

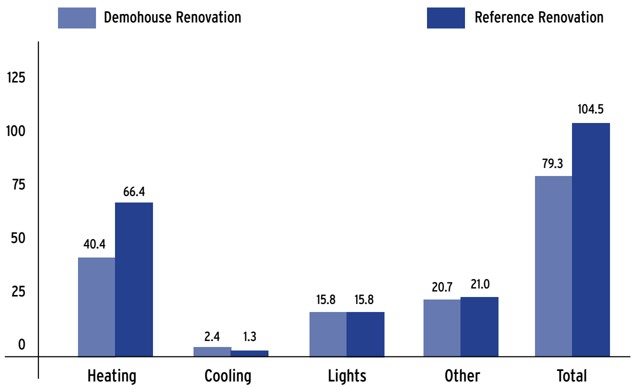
Because of the highly structured building surface and the low amount of space the possibilities for insulation are restricted and ventilation with heat recovery is not possible. Therefore the main aim of the demonstration project is not only the energetic improvement of the buildings but also the reduction of the CO_2 emission. This is reached by the refurbishment of the whole building envelope and all windows to an optimal energy efficiency standard (as possible). An analysis of the energetic performance both of the reference and the pilot project in Energy-10 (dynamic simulation program) and simulations and optimisations of the thermal bridges with the finite element software THERM have been done. Improved thermal insulation, economically optimised have been implemented, e.g. insulation of wall increased from 6 cm in original design to 10 cm, roof insulation from 16 cm to 25 cm, windows from 1.7 to 1.3 W/m²K.

DEMOHOUSE RENOVATION



Monthly Average Daily Energy Use

ANNUAL ENERGY USE



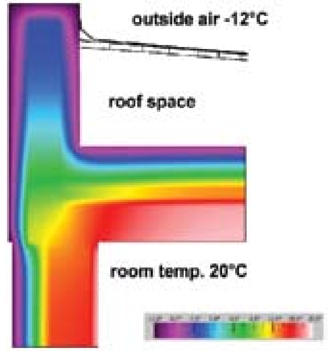
After renovation: view from South-East

The energetic measures related to the building construction in detail:

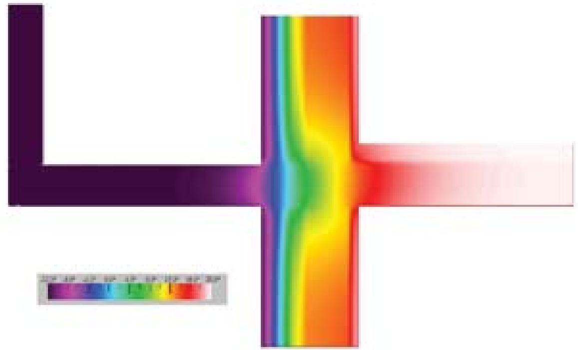
- 250 mm insulation of the flat roof (with recycled cellulose fibres).
- 100 mm insulation of façade (with mineral fibre boards).
- New energetic optimised windows (low-E glazing with U-value 1.1 W/m²K, U-value frames 1.5 W/m²K).

Simulation of thermal bridges has given support to the detailed planning and tendering phase. Because of the tight budget frame the balconies, although being serious cold bridges, could not be replaced. Detailed simulation of this cold bridges have shown that no problems with building physics will emerge.

After renovation: Eastern façade



Simulation of the thermal bridges: profile through attic



Simulation of the thermal bridges: profile through concrete balcony

BUILDING CONSTRUCTION

Life cycle assessment (LCA) for building materials of the thermal envelope based on three ecological indicators (Primary Energy Content - non renewable, Global Warming Potential, Acidification Potential), using the Austrian data source "ö-box", has been done. Calculation of three standards (reference building – standard, demonstration building - standard, demonstration building/BAT - standard) generated decision support to the choice of ecological building materials (e.g. use of cellulose fibres instead of extruded polystyrene for the roof insulation).

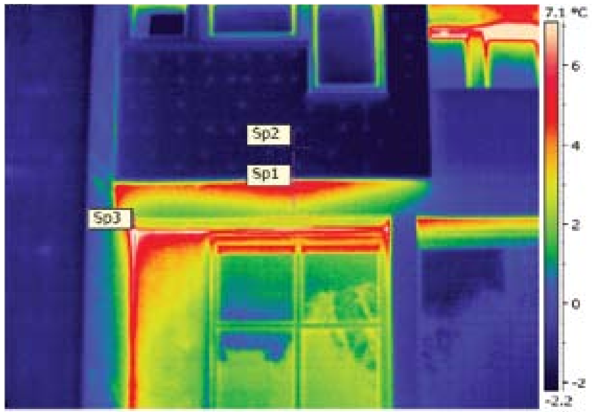
LCA of the thermal building envelope - PECnr, GWP, AP				
	Ecological quality of insulation materials	Primary energy content non renewable in MJ	Global Warming Potential in kg CO_2 equ.	Acidification Potential in kg SO_2 equ.
Reference Building	standard	18,747,467	839,122	7,882
Demonstration Building	standard	21,744,461	1,047,217	9,216
Demonstration Building	BAT	14,583,090	598,042	7,397
standard: mineral wool, plastic windw frames BAT: mineral foam bord, cellulose, wood-alu window frames				

MONITORING AND QUALITY CONTROL

Thermographic pictures of the current renovation status have been taken, disclosing some problems concerning the building physics (lack of insulation). Further thermographic pictures and blower door tests will be done in the monitoring phase, from October 2007 to October 2008.

Energy data and additional results

Energy savings (units are kWh/m² gross floor area)		
Energy saving measures, heating	kWh/m²a	Total (kWh/a)
Low energy windows	12.03	152,095
Improved insulation of the façade	7.26	91,788
Total heating energy savings	19.29	243,883



Thermografic picture of an unforeseen thermal bridge

Economy

Energy saving	Additional costs to	Savings to	Simple Pay-back
measure/investment/ savings/payback	reference building (standard renovation) (EUR)	reference building (standard renovation) (EUR)	periods (a)
Low energy windows	+ 23,169	- 8,734	2.7
Improved insulation of the façade	+ 116,737	- 5,271	22.1
TOTAL	+ 139,906	-14,005	10.0

First hand experiences

The budget frame for energy efficient renovation of social housing projects in Austria (Styria) is rather small. Social housing companies are engaged by social housing law to guarantee affordable rentals for the tenants. Therefore the optimisation of technical measures have to go hand in hand with financial issues and the final design has to be based on the comparison of different renovation variants. For innovative technical solutions (e.g. CHP) alternative financial and management models, like third party financing, have to be developed. To achieve the planned targets, monitoring and quality control (thermography, blower door test) are very important.

New situation around the entrance, after detection of thermal bridge with thermography