EI-Education guidebook on energy intelligent retrofitting

Intelligent Energy Europe

The parties that have participated in developing the guidebook and the education programmes are

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More information on:
http://ei-education.aarch.dk

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EI-Education on Energy intelligent retrofitting

Introduction

In recent years most of the European Unions countries – old and new - have modified their housing, construction and land-use planning policy to prioritise the issue of sustainable development. In a number of countries, projects have been established to showcase and demonstrate the feasibility of adopting a range of measures to reduce the negative environmental impact of housing including the reduction in electricity, heat and water use.

The requirements of the Kyoto Protocol, in relation to reducing CO_2 emissions, are reflected in the policies and initiatives to improve energy efficiency. The EU has recently (March 2007) agreed upon a 20 % reduction of the CO_2 emissions by 2020.

But up till now the focus has mainly been on new buildings. In the existing housing stock the need for improving of the energy efficiency is still an objective issue. As some of the largest, organized actors in the housing sector in Europe, the social housing companies and municipalities have an important task in initiating energy savings in their properties.

Seeing the properties as resources for the future, the question is not only about saving energy, but also about providing adequate living conditions and improving living conditions in general to future standards – also for low income groups.

The strategies and measures described in the "EI-Education Guidebook" are intended to help and inspire the key actors in social housing sector (housing associations, housing companies, municipalities and other owners in social housing sector).

The guidebook and the platform

The EI-Education Guidebook gives an introduction to the strategic, the tactical and the practical level of energy intelligent retrofitting. At all levels the focus are on techniques as well as organisational and financial conditions for implementing energy intelligent retrofitting.

You will find the EI-Education guidebook at the Internet platform together with more information on strategies, planning the energy savings, tools and checklists on how to do. Further more you will find a database of best practice examples, catalogued in "Tecnology and environment", "Policy and strategy", and "Organisation and financing". The address of the platform is:

http://ei-education.aarch.dk

The EI-Education Guidebook and platform have been introduced and trained at national courses (see the website for further information), they can be used as an "encyclopedia" or for self-studies in an e-learning process.

The important thing is – to save energy!

Best practice example as inspiration from Sweden – see chapter 5.

Reading guide

The EI-Education guidebook is a guidebook that you can print or read, or you can find it as a virtual guidebook on the Internet.

The idea with the guidebook is that you can pick what you need in the chapters.

Chapter one gives you an overview of the situation in the six partner countries. This chapter is for your information – it is not necessary to read to use the guidebook.

Chapter two represents the political and strategic level. It gives you inputs for the discussions in your organisation – from general information on the EPBD (Directive on Energy Performance in Buildings) over metering and energy book-keeping to financing concepts.

Chapter three is a presentation of relevant best practice technologies. For each technical element is a description of why and how to use it. The descriptions are meant to be a help in deciding how to renovate. The descriptions can also be used as a "Technical Energy Savings' Encyclopedia".

Chapter four presents a number of checklists and tools that can help you implement energy savings in a concrete project.

In Chapter five you can see a number of inspirering best practice examples, which have all saved al least 30 % of the energy consuption compared with the situation before the renovation. The examples come from 11 different countries in Europe and are categorized in three groups:

- Technology & Environment
- Organisation & Financing
- Policy & Strategy

Chapter six is listing typical drivers and barriers for energy intelligent retrofitting in Europe – and recommendations on how to manage the processes and continue the important work.

In Chapter seven you can see references and recommended reading.

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1. Status quo on energy intelligent retrofitting in the partner countries

After the Second World War the rapid growth of population and growing economy created the need for dwellings and stimulated intensive construction of social housing. Due to the circumstances the durability, energy efficiency and sustainability were far less important that the quantity of flats. This trend reached its peak in the 1970'ies. Nowadays this housing stock usually needs technical and functional renovation as well as social regeneration.

The need for renovation is different in the different countries of Europe. In general, the old member states of the EU have started the renovation process, which considered energy saving measures in relation to the first energy crisis in the 70'ies. These countries have significantly reduced the energy use in the housing stock during the last part of the twentieth century.

The energy performance of the dwellings in the new member states lags behind and is in most cases at least twice as high. Especially the housing blocks build between 1960 and 1990 have very high-energy intensities meaning that the quality of these dwellings from an energy efficiency viewpoint is very low.

The available data regarding levels of refurbishment of dwellings in European countries are few according to the report "Regular National Report on Housing Developments in European Countries". It's not possible to say anything in general on the tendencies of refurbishment in Europe. Countries act very differently concerning refurbishment – independent on whether they are old or new members of the EU. But as legislation normally regulates new buildings, there is still a very large part of the existing housing stock in Europe that needs renovation.

In the following, the situation in the partner countries regarding the renovation of the residential building stock is shortly described.

Short story on renovation status in the six partner countries – an introduction to equalities and differences

Austria

In 2002, the stock of dwellings in Austria included 3,316,000 residences. This constitutes 412.4 dwellings per 1,000 inhabitants, which is close to the average for Europe. 56.9% of these dwellings are owner-occupied – which is a rather low rate of home ownership in the wider European context. Singlefamily houses were the most popular type of dwelling among this group. In 2002, 81% of Austrian owner-occupiers lived in dwellings of this type. In 2001, 40.7% of the Austrian housing stock was rented. Disaggregated data regarding the division between private and social rented dwellings are not available.

In 2002, 96% of main residences had piped water, a lavatory and a heating system, and 87.3% had central heating. Only 3.3% of main residences lacked all these facilities or only had piped water. The average size of Austrian dwellings is close to the average for the countries in Europe. In 2002, 77.8% of main residences had a usable floor area greater than 60 m2.

Social housing and energy refurbishment

The renovation of apartment blocks is supported by the Upper Austrian government. In 2005, more than 180 multi-family buildings were renovated, achieving now an average energy performance indicator of 49 kWh/m²/a. (what is it??? 49 kWh/m²/a for heating only, included tap water and electricity?)

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Bulgaria

After the Second World War the migration from the villages to the towns lead to a huge demand for dwellings. To solve this social problem was implemented the panel type construction of big dwelling buildings. In the period 1960 – 1995 were erected 18.900 panel dwell-

ing buildings with 707.441 dwellings. In these dwellings live more than 2.000.000 people, more than 25% of the population.

After 1990 these flats were sold to the tenants and now 97% of the dwelling stock in Bulgaria is privately owned.

The lack of organisation of owners in these buildings is one of the main barriers towards the organisation of their refurbishment. In order to overcome this barrier a new “Law for ownership” is elaborated in February 2006 by experts from the Ministry of Regional Development and Public Works. This law will support the formation of Associations of owners. The same Ministry adopted a National Program for Refurbishment of Dwelling Buildings in Bulgaria. This programme foresees 20% of the costs of the refurbishment of 684.676 dwellings in big residential buildings erected with reinforced concrete panels to be subsidized by the state. To get these subsidies, the refurbishment should include the implementation of energy saving measures.

Social housing and energy refurbishment
According to the regulations in force since March 2005, all existing buildings with useful area more than 1.000 m^2 are subject to building certification at major refurbishment that costs more than 25% of the total value of the building. After the refurbishment these buildings should meet the new requirements for energy characteristics.

Denmark
The majority of the social housing stock in Denmark is built after the Second World War. In the 1970’ies and 1980’ies, the pre-war stock was renovated to a modern standard with new bathrooms and kitchens and central heating. The post war stock was insulated according to the standards of the period.

The housing stock from the 1950’ie, 1960’ies and 1970’ies is now being renovated – with focus on the living standard and – to some extend – energy saving. The drivers for the renovation are fear of vacancies, and fear of ghettoisation.

The organisation of the housing associations is changing these years – the housing associations are being merged, developing new and bigger organisations to meet the challenges of the present and the future.

Social housing and energy refurbishment
According to the building regulations valid from 1 April 2006 all major renovation projects need to follow a changed guideline. Renovation that involve more than 25% of the building envelope or cost more than 25% of the total value of the building will have to apply to the new and stricter building regulation, implementing the EPBD – the EU Directive on Energy Performance in Buildings

France
France is characterised by a relatively equal distribution between the number of home-owners and the number of tenants: in 2004 55% of French people own their own homes (51% in 1984) and there are slightly more tenants in the private sector (21%) than in the social sector (18%).

France is also characterised by the existence of a low-rent housing mechanism (HLM), the primary manager of local housing in the country (900 organizations, 300 public offices and 340 privately-run companies).

A thousand or so HLM organizations accommodate roughly 13 million people in France. As well as the 3 400 000 rental properties owned by the HLM organization, there are 1 300 000 housing units which are earmarked for social home ownership.

60% of the social housing stock has been erected prior to the first oil crisis. The advanced age of this housing stock makes it vulnerable to accelerating obsolescence:

- from a technical point of view (degradation of the structure, ageing of construction methods and procedures);

- from a design point of view (localisation outside city centres, urban and architectural forms which are outdated);
- from a sociological point of view (degradation of the public image of the HLM organization, an increased awareness of environmental issues).

This is the reason for which the refurbishment of the HLM housing stock has been a priority for the government within the framework of its social housing policy.

Social housing and energy refurbishment
Until recent years, little attention was paid to stimulate energy savings in the social housing sector. However, in August 2004, the French government issued the "Climate Plan" that is an action plan drawn up in order to respond to the challenge of climate change.

Most actions described in the Climate Plan are addressed for new buildings but a number of legislative stipulations were issued for existing buildings. Thermal regulations will be in effect for the very first time for all major renovation work on existing buildings. Energy performance thresholds will apply for some items of equipment when renovation work is scheduled. The French Agency for Housing Improvement (ANAH) will grant subsidies as an incentive to carry out work to improve the overall energy efficiency of residential dwellings. Over a period of five years 200,000 advanced-age housing units will be replaced with new units that meet the new building codes.

An energy performance diagnosis will be compulsory prior to sale (in 2006) and prior to leasing (in 2007). The diagnosis will help identify any energy saving investment needs. After the diagnosis is complete a new Energy Label indicating the building energy performance will be mandatory. Owners who perform work to improve their «Energy label» rating will be eligible for a reduction in property tax granted by the Local Municipality. The 15% tax rebate for owners who purchase energy efficient equipment (high-performence boilers, double glazing, solar-powered water heaters, etc.) will be increased to 25% (up to 40% if renewable energy sources are used). The rebate will be tailored to target more energy-efficient products.

The Netherlands
Most of the Dutch housing associations exist since the beginning of the twentieth century, when the Housing Law gave private non-profit organisations the possibility to build and to manage low cost rental houses, fully financed by the State. The housing associations were operating at municipal level only. In cities where no housing association was functioning or where housing associations were not willing to expand their housing stock, the municipality was obliged to fulfil the housing needs.

In the mid 1990'ies the housing associations became financially fully independent of the state, and they were allowed to operate at a regional and national level. Many housing associations merged, in many cases with the independent operating municipal housing departments, towards large professional bodies, some of them owning more than 50.000 dwellings. In general, they are financially strong.

The majority of the housing stock owned by housing associations is built after the Second World War. In the 1970'ies, the pre-war stock was renovated on a high level: sometimes enlarged, technical improved, insulated where possible towards the standards of that period, optimisation of the floor plans. During the renovation, the occupants moved to temporal dwellings.

Social housing and energy refurbishment
The post war stock was insulated in so-called insulation projects, where overdue maintenance was combined with insulation according to the standards of the period. In far the most cases the occupants stayed in their dwelling during the work.

In abstract terms, housing renovation is adapting the house to new specifications. The original specifications are more or less obsolete.

There are new requirements about energy performance, social structure of the area, comfort of living, etc.

Slovenia

Slovenia, like other central European countries in transition, has experienced major changes in the field of housing. Compared to them, the privatisation of the socially owned flats in Slovenia has been the most extensive. The ratio between individually owned flats and flats for rent prior to the privatisation of flats was reflected in the ratio 66.9% to 33.1%, and after the privatisation was completed, in the ratio 88% to 12% in favour of individually owned flats.

The classification of flats for rent in Slovenia is somewhat specific. The Housing Act adopted in 1991 distinguishes between flats that can be rented freely at market prices, non-profit flats which are part of the instruments of social policy in the field of housing and for which the rent is regulated by statute, and social flats for the low-income population. There is no difference in the quality and the location between non-profit and social flats since uniform housing-construction standards are in force in Slovenia.

Since 90-ties the key actors in the area of social housing supply in Slovenia are municipalities and non-profit housing organisations. According to the Housing Act, it is the duty of municipalities to build social flats and allocate them for renting. Non-profit housing organisations – legal persons established with the aim of ensuring the public interest in the field of housing - acquire and let non-profit flats out for rent.

Important actors in promotion of energy refurbishment are municipal housing funds and non-profit housing organisations, which are responsible for investments, maintenance and refurbishment of the (social / non-profit) building stock.

Social housing and energy refurbishment

Although the social flats for rent (in the narrow sense of word) are low in number, one must be aware of the fact

- that especially older social flats are placed in the buildings with mixed ownership (private owners occupied and other type rented flats) and

- that also many of private owner occupied flats are subject to low income problems, that influence investments in energy refurbishment in the buildings.

Thus the efforts for social housing energy refurbishment are oriented to majority of buildings built in the period 1945-1980.

The buildings built until 70-ties do not have any thermal insulation. In addition, compared to the housing stock originating before Second World War or earlier, the walls are thinner which leads to the poor energy performance. The situation improved after 1970 when the first regulation about thermal insulation came into force. The first serious thermal insulation regulation was promulgated in 1980.

For the last ten years energy advisory programme and state subsidies are available for energy refurbishment. The energy efficiency standards from 2002 regulation should be met, while EPBD driven regulation (expected in 2007) shall soon impose even more detailed and demanding requirements for building energy refurbishment.

2. When to renovate

2.1. Introduction

In spite of the fact that the framework conditions for social housing renovation are different across EU, one can identify common barriers that prevent substantial growth in the number of renovation projects within the social housing sector.

The aim of this chapter is to describe the necessary preconditions for renovation of social housing in order to develop a renovation project at a proper stage in the building lifetime so that they benefit from the framework conditions.

In many EU countries the number of refurbished residential buildings is far to low compared to the energy saving potential identified. And if the decision for the renovation is taken, innovative RES (Renewable Energy Sources) and RUE (Rational use of Energy) technologies with significant contribution to reduction of energy use are rarely implemented.

In spite of the fact that energy efficiency and use of renewables have been recognised as a key element of living comfort, affordable energy costs and contribution to reduction of greenhouse gas emissions the social housing sector has to overcome organisational and financial barriers in order to foster the renovation of the existing social housing stock.

Fig. 2.1 Social housing renovation in Ljubljana, Slovenia

The increase in number of renovations of social housing and consequently the improvement of energy efficiency are subject to favourable preconditions (awareness, availability of technologies on the market, economic feasibility of renovation projects, subsidies) that are necessary for stimulating the investments and thus meeting the strategic national and EU targets in the domain.

Renovation of social housing is hindered by organisational, financial and technical reasons.

Organisational barriers need special consideration in new member states where in the 1990'ies a large amount of the social housing stock was privatized. Privatisation created mixed and very scattered ownership of apartment buildings, since each flat is owned by a different private owner, what requires a lot of reconciliation in planning and execution of maintenance and refurbishment as well as problems in getting required level of consensus needed for technical improvement. In such communities we can often face with a low social capital, i.e. lack of willingness to implement the changes. The negative attitude to renovation of some building owners is a barrier, that can be a consequence of their low income, age, priorities etc., but as a result the consensus for renovation in such situation is not easily achieved.

The core reason for financial barriers is rather low rent in social housing, often administratively prescribed, and far from being sufficient for maintenance and renovation.

Technical barriers are mainly problems with overlooking and prioritising the refurbishment. There are a lot of RES and RUE technologies available - that a building owner must be know with to some extend in order to be able to go into a qualified dialogue with a competent expert at an early stage of the refurbishment planning.

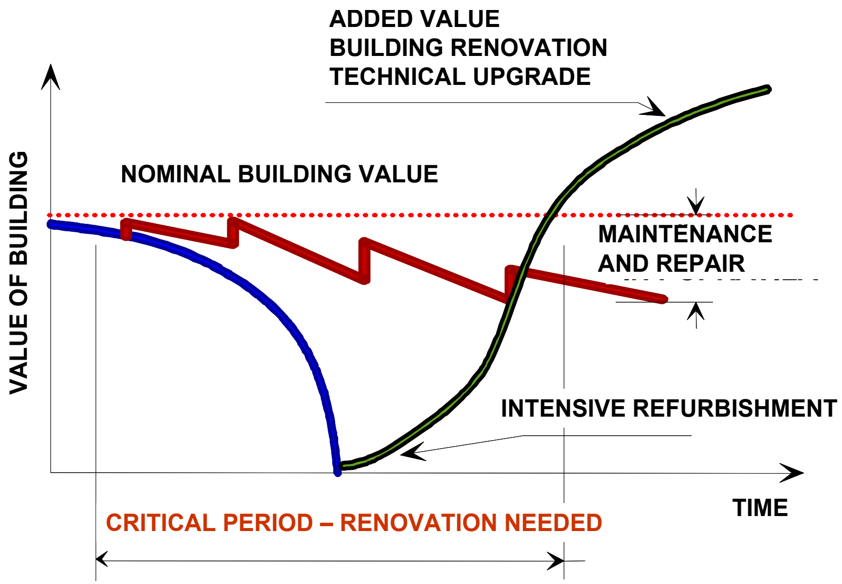


Fig. 2.2 Regular maintenance and repair as well as investments in technical upgrade of the building elements results in higher value of the buildings (Source: Building materials, R.Zarnic, 2003).

Regular maintenance and repair of a building is a guarantee for maintenance of its nominal value (Fig. 2.2). The negligence of regular maintenance, which often occurs in social housing, leads to deterioration of the building quality, functionality and value. Only an intensive refurbishment can return the building to its original value.

On the other hand the systematic approach to building refurbishment, following the state of the art in building technology, principles of whole life costing and the functional requirements of building users leads to an increase of the building value, rationalisation of operational and maintenance costs, reduction of energy use and emissions and to better living conditions. Technical upgrade in building renovation represents and added value of the building renovation process.
A holistic investigation of the renovation measures in the early planning phase can help to find the renovation strategy with the long term benefits.

2.2. Drivers and preconditions for renovation

In the following part different drivers and preconditions that create favourable framework for building renovation projects are described. They have to be considered during the planning of building renovation.

2.2.1 Complete renovation of building

Inadequate functionality of building for living patterns of a contemporary citizen as well as degradation of physical properties of the building envelope may lead to a decision for a complete building retrofit.

Bigger housing companies owning large number of flats have successfully implemented an approach where the tenants are moved to a temporary dwelling, while the entire residential building is going through renovation. The measures can comprise merging and dividing of flats, additional balconies are added in order to improve living conditions and to extend the living space.

But the most important fact is that in such an intensive renovation there is an opportunity to implement not only insulation measures on the outer envelope (added external insulation and replacement of windows), but also to undertake more ambitious building measures like proper zoning of dwellings with respect to the location and solar radiation and other strategies to use solar energy and to install energy efficient HVAC and renewable energy technologies. It might often be a more ‘clever’ renovation to combine retrofitting measures instead of just doing singular measures.

After the renovation many of such intensively retrofitted buildings reach low energy standard due to incremental investments in energy efficiency. Due to the energy savings achieved such retrofitted buildings often become “shinning examples” in the local context.
In many countries subsidies are available to support this approach. Unfortunately in some countries (mainly new member states), where the privatisation of the social housing stock has been implemented in

the 1990íes, this approach resulted in a scattered and mixed private – public ownership of residential buildings.

The specifics in ownership and consequence in decision making represent an important barrier for implementation of the above mentioned holistic approach to building renovation.

2.2.2 New tenant in the flat

The flat is normally renovated when a new tenant is about to rent the flat. The housing company can at that stage implement some major refurbishment works related to windows, walls and installations. Due to the fact that the dwelling is an integral part of the apartment building there are some measures that can be done for improvement of energy efficiency, like replacement of windows in accordance to architectural requirements, drought-proofing, reduction of thermal bridges, implementation of compact devices for mechanical ventilation with heat recuperation, local regulation of heating and installation of energy efficient boiler for hot water preparation.

2.2.3 Renovation of building elements at the end of their lifetime

The implementation of energy efficiency measures when the refurbishment or replacement of particular building element (window, outer wall render, boiler etc.) is needed due to its age creates a “win-win” situation. When the service lifetime of the building element or HVAC system expired, the replacement is needed for functional and safety reasons. The investment in energy efficient products instead of just keeping the original technical standards, means that only incremental investment in energy efficient technology was needed to reduce the heat consumption. This approach makes energy efficiency investments in building renovation economically attractive and competitive.

It is thus important that the renovation measures which include also investment in energy efficient technologies go along with the building maintenance, like:

- when the building envelope needs refurbishment it is wise to install additional layer of thermal insulation,
- when the window frames are at the end of its lifetime, it is a good opportunity to install new windows with low-e glazing and
- when the boiler is above 15 years old, it is necessary to do significant renovation and investment in the whole heating system, to improve the energy efficiency.

Often it is difficult to make a decision among different options. A systematic approach to identification of renovation needs and to evaluation of refurbishment scenarios is needed (see Chapter 4 – Checklists & tools).

2.2.4 Major renovation according to EPBD

The EPBD – the Directive 2002/91/EC of the European Parliament and Council on energy efficiency of buildings was adopted on 16th December 2002 and entered into force on 4th January 2003. It is considered as a very important legislative component of energy efficiency activities of the European Union designed to meet the Kyoto commitment and responds to issues raised in the recent debate on the Green Paper on energy supply security.

The Directive is set to promote the improvement of energy performance of buildings with four requirements to be implemented by the Member States:

1. General framework for a methodology of calculation of the integrated performance of buildings
2. Setting of minimum standards in new and existing buildings
3. Energy Certification of Buildings
4. Inspection and assessment of heating and cooling installations.

Member States shall take the necessary measures to ensure that when buildings with a total useful floor area over 1 000 m² undergo major renovation, their energy performance is upgraded in order to meet minimum requirements in so far as this is technically, functionally and economically feasible. Member States shall derive these minimum

energy performance requirements on the basis of the energy performance requirements set for buildings in accordance with Article 4 of the directive. The requirements may be set either for the renovated building as a whole or for the renovated systems or components when these are part of a renovation to be carried out within a limited time period, with the abovementioned objective of improving the overall energy performance of the building. (www.buildingplatform.eu)[1]

EPBD Directive set the general framework for refurbishment of existing buildings, including social housing, and requested from member states to implement the minimum requirements for energy efficient renovation of buildings, for inspection of boilers and of airconditioning systems. Furthermore a new requirement for establishing energy certificates can motivate a renovation especially if the certificate is visible to the public. The background of these requirements is defined by a significant energy saving potential in existing buildings and by the fact that intensive renovation of social housing takes place very rarely in a life-time of a building.

In the above conditions it is very important to consider a strategy of building energy restoration and not only the implementation of minimum requested measures. The renovation stimulated by EPBD requirements are subject to economic feasibility of investment, therefore in case of pending renovation scenarios it is very important to consider not only investment costs but also pay back time and life cycle costs of the renovated building.

2.2.5 Energy certificate at selling and renting of a flat

Energy certificate of buildings is a new instrument introduced by EPBD Directive for promotion of energy efficiency in new and existing buildings. When buildings are constructed, sold or rented out, an energy performance certificate must be available to the owner or by the owner to the prospective buyer or tenant. Apart from ranking the building and its flats into the classes according to energy efficiency, the energy certificate shall also be accompanied by recommendations for the cost-effective improvement of the energy performance. Social housing is a very important target group for the implementation of energy certification and due to a frequent renting of flats there will be a great demand for certification immediately after the regulation will be in place. The beneficiaries of the energy certification are not only the tenants, but also the social housing association, that will thus get the guidelines for planning of refurbishment and technical improvement.

In order to facilitate the investments some countries plan to link the certification to various incentives.

The transposition of energy certificate shall be completed in all EU member states at latest by Jan. 2009.

2.2.6 Introduction of heat billing and metering according to actual consumption

Heat billing and metering according to actual energy consuption has already been set as an important goal in all energy efficiency strategies from the middle of 90-ties. Once a fair accounting of energy costs is established then building users gain the motivation for changing of the living habits as well as for the use of energy efficient technology!

2.2.7 Energy book-keeping and benchmarking of energy indicators

Good energy book keeping is the basis for a successful management of apartment buildings and it is often a driver for future investment.

The data on energy consumption can be benchmarked with the energy indicators from previous years in order to identify eventual difficulties in building operation. On the other hand benchmarking within similar social housing sector can assist in setting the ambitious but realistic energy efficiency targets after the building renovation.

[1] This information is obtained from the EPBD Buildings Platform, an initiative from the Intelligent Energy – Europe Programme of the European Commission. For more information, newsletter subscription, disclaimer and copyright notices, see www.buildingsplatform.eu

Benchmarking of energy indicators can be done either on the building level, in order to facilitate the investments in renovation, or on level of flats, in order to identify the specific rules in user's behaviour.

Once the energy consumption indicators are collected they represent valuable initial information for a consultant preparing an energy audit, which is concluded with the list of recommended investment in refurbishment.

23.2.8 Benefit from demonstration projects

Shinning examples give motivation for further replication of successful energy restoration projects in social housing sector. Currently, there are quite some demonstration project available in EU, some of them are also evaluated and presented in EI-Education project. The comparison between "before and after" case is one of the most decisive situation

2.2.9 Information and educational activities

Awareness raising, information and educational activities are very important in the social housing sector. New energy efficiency technologies in buildings require more complex technical understanding. When the system is well tuned during the operation phase the maximum energy savings can be expected.

An educated tenant, that among others understand also how to use energy efficient technology, and trained experts in housing companies, that understand the energy refurbishment plan (what to implement), are essential for achievement of energy efficiency targets

2.2.10 Energy performance contracting - Third Party Financing TPF

Energy performance contracting is a very promising financial instrument to overcome the most frequently identified barrier in social housing sector, i.e. the lack of money for investment in energy efficiency and in refurbishment in general.

Energy performance contracting (also called third party financing – TPF) is a practical and effective way to finance and install energy-efficient technologies, improve the building's energy performance – and save money and energy.

The basic principle of contracting schemes is quite simple. An energy service company (ESCO) provides his know-how and in many cases also his financial means to a project. Two basic approaches to contracting are: Energy Performance Contracting (EPC) and Delivery Contracting (DC). While EPC reduces energy bills by increasing efficiency of the building, Delivery Contracting targets only the production of heat, cold, or electricity through the ESCO.

For an EPC project, an ESCO provides its know-how for energy saving measures in buildings and carries out the investment. The ESCO takes on the performance risk and guarantees that adequate measures are implemented and the stipulated energy savings are achieved.

The investment is refinanced through the savings (Fig.3.3) gained in the main phase of the project. Depending on the agreement between ESCO and the building owner a part of the energy savings can be allocated also to the building owner in order to slightly reduce their energy bill and create the motivation for energy savings. Once the contractual period is over the investments as well as the energy savings belong to the building owner.

Energy performance contracting is widely implemented in public buildings, where the building owner, investor in refurbishment and the user of the building is the same entity.

It is a challenge for a social housing to further develop the contracting scheme and implement energy efficiency projects which pay for themselves by the energy savings, and in principle require no initial financial investment from the social housing side.

The barrier for the implementation of contracting in social housing is the fact that the renovation costs are to be paid by the building owner, while the energy savings are demonstrated through lower energy bills that are paid by the users. But assuming some modifications in the scheme also the social housing owners and users can benefit from contracting.

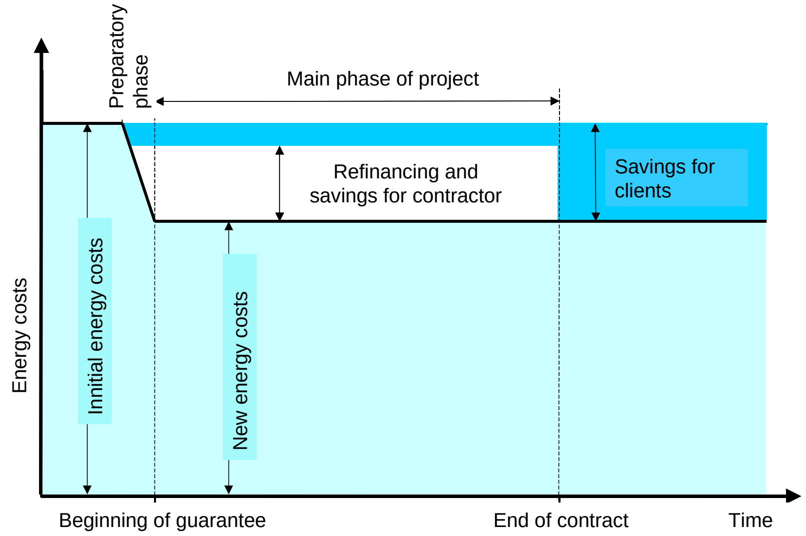


Fig. 2.3 Energy performance contracting – scheme of financial flows (Source: Energieeinspar-Contracting, Ein Leitfaden für Kommunen, ZREU)

To facilitate the use of contracting in social housing the social housing companies and tenants should conclude an agreement, about the benefits tenants have due to energy efficiency investment (better living conditions and lower energy costs) and about the payment of these benefits within the rental.

The investment in energy efficiency and the technical improvement should reflect in higher rentals of the renovated buildings. Thus the social housing companies could guarantee the refinancing of ESCO investments.

2.2.11. Financing energy efficient renovation in social housing

Existing residential buildings offer large technical energy saving potential comparing to other building sectors. To overcome the financial barriers and to realize this energy saving potential EU countries developed various programmes of incentives to stimulate the building owners to invest not only in standard but also in better RES and RUE technologies. This approach contributes to achievement of low energy standard also in building refurbishment.

Incentives:

- Subsidies for investment
- Soft-loans for investment
- Revolving fund for energy efficiency investments

Financial subsidies for selected refurbishment technologies are one of the most common incentive measures for EE refurbishment in housing sector.

2.2.12 Policy plans – future possibilities

Contribution of renovation to achieving the targets of regional energy strategies or other relevant strategies – like property development plan, 10 years plan etc. The aging and deteriorating housing stock increases the need for refurbishment; so extending the lifetime of the existing housing stock represents a far cheaper option than building new houses (INOFIN report). Housing refurbishment and increasing the energy performance will make the housing stock more attractive; possibility to increase rent of rental housing and increase of real estate value of owner-occupied dwellings (INOFIN report).

A possibility to realizing refurbishment projects is to combine renovation projects in order to minimize both the costs and the troubles of the existing tenants. An example of this is the refurbishment of a Dutch housing cooperative in the town of Veenendaal where two apartment buildings each containing 75 dwellings with a floor area of 95-100 m^2

were refurbished. The goal was to replacement of an out-of-date heating system, lengthen the life span of the buildings with 15 years and to accomplish major energy savings.

At first, the tenants were not enthusiastic about large-scale refurbishments. They were satisfied with their apartments, their neighbourhood and their comfort. Intensive consultation with tenant representatives showed them the comfort improvement and financial benefits of the project. Comfort is improved because of: a more optimal space heating with smaller radiators, better measure and control equipment, more living space in the kitchen without boiler or geyser, no toxic emissions from a geyser in kitchen, unlimited hot tap water and better air quality because of ventilation. Financial benefits came from a decrease in gas use and no electricity use for hot tap water. Tenants have to pay their heat in advance. The cooperative promised beforehand they would charge less in advance directly after the refurbishment. This convinced people that the project would really be beneficial for them. To limit the nuisance from construction works, all construction work inside a single apartment was concentrated in two days. To achieve this, the new heating pipes were not built inside apartments or boxrooms, but on top of the building roofs. With this method, a large part of the heating system could be constructed without any discomfort for the tenants.

The total costs for the project were € 1.24 million. This means that the average costs per apartment were € 8,327 (excl. VAT about € 85/m^2). An amount of € 1,044 per apartment was subsidized because of the use of solar energy. The remaining investments were done by the housing cooperative. Their benefit from the refurbishment is mainly the lifetime extension of about 15 years. This means revenues from rents for an additional 15 years. Because of this integral approach, no rent increase was necessary to finance the refurbishment.

The integral and strategic approach is the main driver for success in this project. Energy saving is seen as part of a broader goal to lengthen the life span of buildings. (INOFIN)

2.2.14 … noget fra Evelina - interesting case study, no.4 from Bulgaria????

References and additional reading

More details on EPBD can be found on the following homepages:
www.buildingsplatform.org -This is an EU- website of the EPBD Platform. You can find there a database with publications, news brief, etc.

www.epbd-ca.org - This is a website of the EU Concerted Action on EPBD. The members are Ministries of Environment and their executive organisations. The site is devoted mostly to policy matters. Newsletter available.

www.cecodhas.org

Link to brochure about Energy Contracting (in German):
http://www.energiesparverband.at/esv/fileadmin/esv_files/Info_und_Service/Contracting_Brosch_re.pdf

InoFin project: Report: "Experiences with financing social housing refurbishment WP2 overview report for the InoFin project", M. ten Donkelaar. ECN-E--07-012 February 2007. Link to report:
http://www.ecn.nl/publicaties/default.aspx?nr=ECN-E--07-012v

Report: "Financing energy saving measures in the Dutch social housing sector. WP2 report to the InoFin project" M. ten Donkelaar, Y.H.A. Boerakker, B. Jablonska, C. Tigchelaar. ECN-E--06-049 December 2006. Link to report:
http://www.ecn.nl/publicaties/default.aspx?nr=ECN-E--06-049

3. How to renovate

3.1 Introduction
This chapter is an introduction to relevant best practice technologies you can utilise in connection to energy efficient renovation of social housing projects.

The focus is on how to reduce the energy consumption for heating domestic hot water DHW, and electricity use for operation of fans and pumps as much as possible. Also water savings are relevant in general since it affects the DHW use. Besides needs for circulation of DHW should be reduced / optimised.

Furthermore it is obvious also to use renewables like solar heating or PV electricity to cover part of the reduced energy demand. And it is necessary to introduce an optimised general energy supply solution with reduced losses like e.g. district heating, gas heating or use of heat pump. Here it is important to focus on a low level of heat losses from distribution of both heating and domestic hot water. Especially in low energy renovation projects there can be considerable heating loss compared to the reduced energy use.

The energy use for heating can be reduced by use of extra insulation of walls, floors and roofs. Here it is also important to focus on possible cold bridges and limit the effect of these. E.g. in concrete housing blocks you often have a balcony where the concrete is direct connected without any insulation to the interior of the dwelling. A solution here could be insulation with a hard insulation material. Besides it is optimal to use energy optimised windows especially windows with low frame losses. Finally as one of the most important future solutions it is necessary also to consider energy savings in connection to ventilation which can be a very considerable part of the total energy demand. Here new ventilation solutions with low cost and high-efficiency heat recovery are important, also to improve the indoor air climate.

3.2 Best practice technologies
In the following single technologies suitable for renovation are presented. The examples are based on the Green Catalogue project[2].

3.2.1 Insulation
3.2.2 Low-energy Windows
3.2.3 Air-tight Constructions
3.2.4 Double facades and glazed areas
3.2.5 Heat Recovery Ventilation system
3.2.6 Condensing boiler
3.2.7 District heating systems with low losses
3.2.8 Combined heat and power
3.2.9 Heat pumps
3.2.10 Natural, Hybrid and PV-assisted Ventilation
3.2.11 Solar DHW Heating System
3.2.12 Solar wall and air collectors
3.2.13 PV-installations

3.2.1 Insulation
The most efficient strategy for energy saving in buildings is optimisation of heat insulation. Thermal insulation reduces the heat losses due to transmission and is therefore the condition for a low heating energy demand.

The extra insulation can be added from the outside or the inside. Both will have different consequences, e.g. insulation on the outside will change the appearance of the building facade, and insulation on the inside will decrease the living area.

Insulating the roof is a very important measure, which should be given special attention in every building. As warm air goes up, the tempera-

[2] Green Catalogue is an EU-project funded by the SAVE programme. See more in chapter 8.

ture in the upper air layers of heated rooms is always a bit higher. That is the reason why a lot of heat can be lost through the roof.

The insulation of a steep roof can be implemented in two ways: by insulating the ceiling of the top floor if the attic is not heated and by insulating the roof construction itself in case of a heated attic. If the last mentioned kind of insulating the roof is applied, five constructional principles have to be differentiated: insulation between the rafters, over the rafters, between and over the rafters, between and under the rafters and an insulation lying outside.

Fig. 3.1: Different types of insulation (ECN)

It is also important to insulate the cellar. The insulating material can be implemented either on the ceiling of the cellar or under the ceiling of the cellar. In most cases an additional insulation is used to reduce the sound propagation due to subsonic noise. Another aspect to be aware of when isolating is avoiding cold bridges and airtight constructions in order to avoid draught and unnecessary heat losses.

A measure for a material to transmit heat is the heat conductivity (λ), a value that is characteristic for a specific material, independent of the thickness and the integration of the component. The unit of the heat conductivity is therefore W/mK, i. e. it indicates how much heat (W) passes a component of 1 m² with a thickness of 1 m and a temperature difference of 1 Kelvin (K). The lower the heat conductivity of a material is, the better is its efficiency of insulation.

The quantitative heat losses through a component are measured by the coefficient of thermal transfer, the U-value. Similar to the heat conductivity λ it describes the amount of heat that goes through a component of 1 m², when the temperature difference between the inside and the outside is 1 K. Its unit is W/m²K.

Insulating materials are such materials that a characterised by a heat conductivity below 0,1 W/mK. The best available insulating materials have λ-Values of 0,025. However, the materials that are mostly used have λ-values of 0,04 or 0,035. They are fixed as a thermal envelope around the area that should be kept warm. Materials that are on the market have very different consistencies. Only few products are completely made of a single raw material. In general, insulating materials can be differentiated in inorganic and organic raw materials, whereas those can again be partitioned in synthetic and natural materials.

Most of the Best Practice Examples presented in Chapter 5 have used extra insulation in order to reach the low energy level.

3.2.2 Low energy windows

Similar to the insulation of the external wall, the roof and the floor, the insulation of windows has a high impact on the thermal protection of a building. Although the development of the last years is characterised by a big improvement of the energetic quality, windows still have the lowest level of insulation of all external components of a building.

The reduction of the thermal transfer of windows has been reached, as especially the thermal properties of the glazing, which has the highest impact on the heat losses, were improved. Generally there are the following kinds of glazing:

Glazing	U-value for Glazing (W/m^2K)	U-value for Window (including frame) (W/m^2K)
Single	5,8	3-4
Double	3,2	2,8
Double low-Energy	1,1	1,5-1,7
Triple	2,5	2,2
Triple low-Energy	0,7	1,0-1,2
Passiv House (with insulated frame)	0,7	0,8

Fig. 3.2: Overview of U-values for different types of glazing and for the whole window –including frame. The values are for standard windows (app. 1x0,7m).

Single glazing (U-values up to 5,8 W/m²K) are no longer common. In old buildings they might though be found and here it can be efficient to apply a secondary removable window – a so called double window or winter window – on the inside.

Efficient glazing consists of two or three layers pane, which is separated from each other by a layer of air. The heat losses due to transmission are reduced to the half of a single glazing, but they are still very high. That is for example the reason why since 1995 efficient glazing is not allowed any more in Germany to be implemented in a new building. A substantial improvement is the high-efficient glazing with U-values between 0,4 and 1,6 W/m²K. The insulating properties are again 50 - 60 percent better than those of the efficient glazing. On the inner layer there is a very thin emission-reducing metal coating, which reflects the long-waving sunrays back to the room and lets the short-waving rays pass the glazing. Moreover the space between the two layers of glazing is not filled with air but with a rare gas, which has lower heat conductivity. The gas used in most cases is Argon. The difference to the triple high-efficient glazing is, that here the heat losses can be reduced even more through the implementation of a third layer pane and a metal coating on two inner layers.

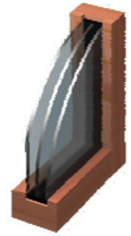


Fig. 3.3: example of three layers glazing (ECN).

The best thermal insulation can be reached, if one of the even better insulating rare gases Krypton or Xenon is used instead of Argon. Altogether the heat loss through a triple high-efficient glazing is still one eighth of the value of a single glazing.

As typical measures of windows consist to 15 – 35 percent of frame, the heat losses due to transmission in the frame are important to consider. Here it is both heat losses through the frame (this is not the case for plastic windows) and heat losses through edges and thermal bridges in the frame. Frames are typically made of wood, synthetic material or aluminium. In new types of insulated frames the heat losses has though been reduced.

Wood is the material, which is characterised by the longest lifespan and is best durability against influences from the outside. Usually, frames made of wood have very good thermal insulating properties. The kinds of wood that are used in most cases are spruce, pine and oak. Frames made of synthetic material are mostly made of polyvinylchloride or polyurethane and can reach values of thermal insulation similar to wood-frames. All in all wood and synthetic materials are those, that with a market share of 80 percent are sold in most of the cases.

The heat losses through the windows are also measured by the U-value. The U-value of the complete window is calculated in dependency of the U-values of the frame and the glass, whereby the frame-U-value mostly is the higher one. Another important value is the g-value. It indicates

how many percent of the sun-rays with a vertical direction go through the glazing into the room.

As the windows are an important part of the thermal envelope energy efficient windows are used in most of the mentioned Best Practice Examples in Chapter 5.

3.2.3 Air tight constructions

There are several reasons, why an airtight implementation of the building envelope is very important:

- The reduction of heating demand: Especially during the winter the thermal lifting results in a high temperature difference between the inside and the outside of a building. Consequently, in the upper part of the building the warmed air flows through points of leakage to the outside (exfiltration), whilst in the lower part of the building cold air pours through untight locations to the inside (infiltration). To assure a convenient indoor climate, the cold air has to be warmed up, so that the unintentional air exchange results in a higher heating demand.

- The avoidance of infiltration: As a consequence of the thermal lifting, the inward flow of cold air into the building generates inconveniences. An airtight construction avoids infiltration.

- Prevention of structural damages: A high air humidity results in the creation of condense, which causes humid areas in the wall because of lower temperatures – and with it structural damages in the building envelope.

To assure an air tight building envelope, moisture brakes or even moisture barriers are attached in order to prevent humidity to get into the construction and the thermal insulation. It is very important, that these foils are fixed very accurately, because otherwise they do not have any effect. The following table shows values for air change pr. hour (ac/h):

Air change pr. hour (ac/h)	
International standard	0,5
Ordinary buildings	0,25-0,4
Low energy houses	0,05-0,1
Passiv houses	0,6
Note: the given values are for 0 pa. When testing air tightness with a blowerdoor each value has to be multiplied with a factor 20.	

Fig. 3.4: Air change pr. hour for different kinds of buildings..

To guarantee a construction without any leaks it is recommended to develop a leak tightness concept and to locate weak points in the envelop by a so-called Blower-Door-Test. In this test a ventilator creates a constant pressure of +/- 50 Pascal (Pa). Depending on the tightness of the building the ventilator has to work more or less strong to obtain a specific pressure in the building. Thus, the measure of untightness can be deduced and with the help of a mist the untight points can be located.

The verification of an airtight construction can be done by the above mentioned Blower-Door-Test. The n_{50}-value indicates how often the complete air in a room is changed within one hour monitored at +/- 50 Pa. In case of a ventilation system applied, this value has to be smaller than in the case of window ventilation.

For examples of use of air tight constructions se Best Practice Example no. 1 from Austria and Best Practice Example no. 4 from Denmark. Both are mentioned in Chapter 5.

Fig. 3.5: Blower Door test in an apartment (CENERGIA).

Fig. 3.6: Example of registration of white smoke movement to trace cracks and crevices in combination with the blower door test (CENERGIA).

Air tight constructions – Practical implementation

The air-tightness should be ensured on the inside of external constructions by help of a vapour barrier of e.g. aluminium foil or plastic film. On the outside wind-tightness should be ensured to protect the building construction against bad weather conditions. The first thing one should do when ensuring the air-tightness of a building is to check the joints between the different external constructions, e.g. the windows/doors and walls. By sealing up joints between the different external construction a good result can be achieved with low costs.

According to the German Passiv Haus Institut the most important rule for achieving good air-tightness is to seal the whole building with an air-tight layer (see Fig. 3.5).

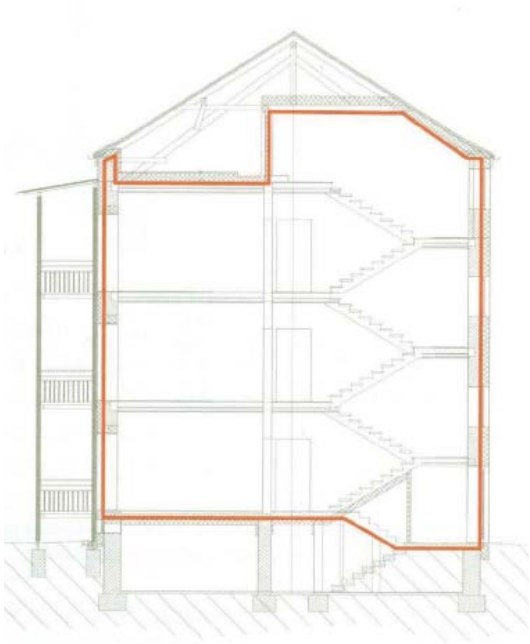


Fig. 3.7: Air tight layer (in red) wrapping the whole building (CENERGIA).

3.2.4 Double façades and glazed areas

Double glazing façades require very careful use. The climate conditions (e.g. air temperature, solar radiation) and the location of the building constitute the main parameters for the use in such façades. In South Europe the abundance of sun year-round and the little cloudiness restrict the extensive use (space overheating) contrary to North and Central Europe where the overcast and low temperatures during wintertime enforce the use of double glazing façades (production of thermal energy).

Double glazing façades are usually planned with an adequate width to incorporate “walk-ways” (for maintenance) that also contribute to the shading needs of the interior façade. In some building cases, the intermediate air gap is ventilated (naturally or mechanically) for avoiding space overheating.

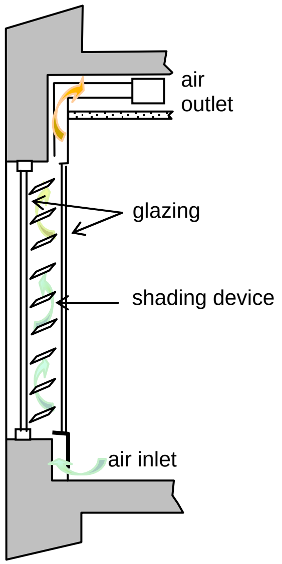


Fig. 3.8: Example of a double glazing façade (CENERGIA).

Glass and double facades are most common in office buildings as they here has a number of advantages. As the gab between the windows is heated the glass wall gets an effect of being insulated which makes it possible to sit close to the window without experience the feeling of a cold draught. Furthermore office buildings has a special need for ventilation and cooling which both (partly) can be done by the glass wall. Depending on the orientation the double glazing façade has different benefits: thermal protection for the north facades with creation of a buffer space, thermal protection for the west facades with removal of the enclosed warm air, and heat production for the south and east facades.

Fig. 3.9: Examples of office buildings with double facades: The Royal Library in Denmark and the Danish insurance company Alm. Brand (CENERGIA).

Shading consists with the basic requirement for all glazed areas. There are many shading products that are either external or intermediate and vary in material and type; the most common are blinds (movable manually or by sensors) and semi-transparent membranes.

Double facades and glazed areas can be made in a number of different ways and every project will have to have its own design according to the given needs. The two shown Danish examples have different designs – one of the projects has a single glazing on the inner side, the other has a single glazing on the outer side. In other cases is would also be possible to use to double glazing. Typical glazed areas are made in order to limit the heat losses and reduce the outside noise. See examples of glazed areas below.

Fig. 3.10: renovated building in Bratislava having a glazed area and an example of a glazed atrium (ECN).

Another way of using the passive solar heat and a very common solution is to make glazed balconies which also prolongs the period the balcony can be used. It is though important to guide the tenants in the use as the glazed balconies may also result in a great heat loss if they are heated in winters.

Fig. 3.11: Example of glazed balconies.

In case of a ventilated intermediate air gap, the inner glazing and the shading devices pollute, because of the airflow. This affects the performance of the system (e.g. reduction of the view factor); in order to avoid unfavourable results the inner glazing must be made in a way so it is possible to open it.

In very high double glazing façades (e.g. over several floors) the main disadvantage is the overheating of the outgoing air (in the upper part of the air gap), which creates a heat radiation and therefore increases the indoor temperature. This can be avoided by air extract on each floor.

The best way to deal with glass construction in general, is the collaboration of architects and energy consultants with guidance of expert glass manufacturers. As such, most of the recent large building projects incorporate glass in innovative ways and double facades (glazed) represents one of these techniques. The performance of a double glazing

façade is defined by the thermal transmittance (U-value), the light transmittance (τ) and the reflectance (R) of the glass.

An example of a glazed facade can be seen in Chapter 5, Best Practice Example no. 1 from Austria.

3.2.5 Heat recovery ventilation system

Because of the increased demands for low-energy ventilation systems in buildings there has been a great increase in development for heat recovery with mechanical ventilation systems, where outlet air is used for preheating of inlet air, is expected in the near future. To reach low value for energy and especially heat consumption in a building a heat recovery ventilation system with high efficiency is necessary. E.g. a passive house can only be realised with high effective heat recovery ventilation.

Fig. 3.12: Illustration of a heat recovery unit placed in connection to the ventilation system in a closet. This solution makes the maintenance easier (CENERGIA).

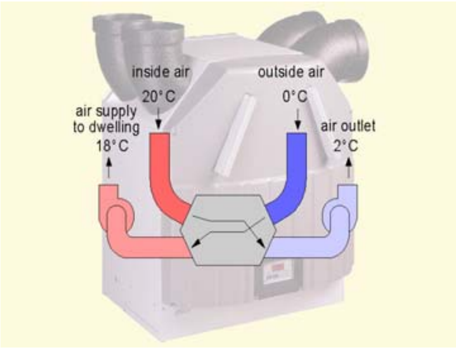


Fig. 3.13: Principle of the heat recovery unit (ECN).

Not only energy consumption is decreased by heat recovery ventilation systems with low electricity use, but also the indoor air quality is improved, which not only is a benefit for the tenants but will also prevent e.g. moisture damage in buildings.

To meet the demands for energy efficient ventilation system the following requirements should be satisfied:

- ✓ The dry efficiency of the heat recovery heat exchanger should be at least 80-90 %.
- ✓ Power consumption of the ventilation system should be only 30-40 W (0,24 W/(m^3/$h_{air\ change}$)) (Danish Building Regulation demand is 87 W).
- ✓ The building should be complete air tight (natural infiltration should be 0,05 /h and never higher than 0,1 /h).
- ✓ The ventilation system should be installed inside the building envelope.
- ✓ The noise level should be less than 25 dB.

It has been aimed to improve electricity efficiency and the actual thermal efficiency. In a new series of fans with backward curved blades the electricity consumption is decreased considerably from the former nor-

mal level. Also a DC engine has been developed where the electricity consumption incl. converter is 20 % below this level.

The main focus should be on individual heat recovery units for each apartment, due to risk of malfunction, more simple control and avoidance of heat losses in a cold loft room. Here there is a big need for solutions with a documented low electricity use and no noise. A solution with individual 15-25 cm thin air to air heat exchangers from the Danish company EcoVent has been developed. These can be integrated along the walls or loft in a simple way and with simple maintenance possibilities (e.g. change of filter). To make it possible to check the low electricity consumption for ventilation an easy check system for this is foreseen.

There will have to be ventilation with heat recovery if the aim is a total energy use below 65 kWh/m^2 per year for heating and hot water. In all cases a sufficient air change of 0,5 per hour shall be acquired. In case of mechanical ventilation max. 0,05 /h air change shall be through natural infiltration equal to 1,0 per hour at +/- 50 Pa blower door test.

User controlled ventilation can be 126 m^3/h or 0,5 /h at normal conditions and 65 m^3/h as a minimum value when you are away. There is a need for summer operation with a by pass function and winter operation with a reduced fresh air amount when the temperature is below -5°C. Relative humidity should not exceed 60 % and filtering is needed.

A reduction in energy consumption can best be obtained with a user controlled ventilation system and use of energy efficient components in optimal designed solutions. Also service and proper cleaning of the ventilation system is necessary. The air velocity for ventilation shall be below 0,15 m/s in rooms to prevent draught problems for the tenants.

See examples of heat recovery ventilation systems in Chapter 5, Best Practice Example no. 1 from Austria, No. 1, 3 and 4 from Denmark, no. 1 from Sweden and no. 5 from Switzerland.

3.2.6 Condensing gas boiler

The condensing gas boilers are used both in single and central heating systems. An optimal use combines a condensing boiler, a heating solar panel and a low temperature heating system (floor heating) so as to achieve an optimal condensation and exchange of latent heat of gas fumes.

From a technical point of view the condensing gas boilers operate in two different fields of temperature with different efficiency: at 50/30°C (between sent and return temperature), they achieve a mean efficiency of 105% (Best available technology – BAT: 107%), while in the field between 80/60°C they achieve a mean efficiency of 96% (BAT 98%).

The energy efficiency of the condensing gas boilers has been increased from the variable flame, where the variation of the air flow in the burner according to instantaneous needs, avoids low efficiency on-off cycles. From the ecological and waste emission point of view, the emissions are respectively: CO_2 9%, NO_x 40-44 mg/kWh, CO 15-19 mg/kWh. The generators available on the market are of various sizes that cover all the requirements of a traditional heating system, but a higher initial investment is necessary.

In the Best Practice Example no. 11 from Austria mentioned in Chapter 5 a condensing boiler is used.

3.2.7 District heating systems with low losses

District heating is a system that transfers and distributes heat from one or more heating plants to residential commercial and industrial consumers for space heating, hot water heating and industrial processes. A district heating system consists of heat production units, which could be a combination of heating-only plants, combined heat and power production plants, waste heat recovery plants, peaking and standby heat plants, primary heat distribution network, substations at the consumer connection points, end-users secondary networks and installations for space heating and domestic hot water.

The heat carrier in the heat distribution system can be either hot water or steam. The hot water in the distribution system can be generated in heating-only boiler plants, in combined heat and power production plants, from industrial waste heat recover, refuse incineration plants or sometimes from geothermal sources.

District heating is a natural solution for provision of heat in built-up areas. It helps keep the environment clean and increases housing comfort. District heating also helps conserve energy and the environment. This conservation is best realised in combined heat and power (CHP), which utilises 80–90 per cent of the energy value of fuel. When electricity is generated separately, the utilisation rate of fuel energy is a mere 40–50 per cent. Thanks to the efficiency of CHP, emissions to the environment are about 30 per cent less than in separate generation of electricity and heat (read more about CHP below). Heat is produced using a varied selection of fuels – natural gas, coal, peat, wood and waste wood, or oil – while also paying attention to overall economy and to the impact on the environment. Useable heat from industrial production can also be utilised for district heating

Heat supply

District heat is generated either together with electricity at combined heat and power plants (CHP) or solely as heat at heating plants. The temperature of district heating supply water varies depending on the country standards and weather, being for example 65-115° C. The temperature is at its highest in winter and lowest in summer, when heat is only needed for hot service water.

Heat distribution

District heat is transmitted from production plants to clients as hot water in a closed network consisting of two pipes (flow and return pipes). District heating pipes are laid in the ground, usually at a depth of 0.5 to 1 metre. The pipes have effective thermal insulation. On an average, heat losses in the distribution network account for less than 10 per cent of the energy transmitted in the pipes.

The water circulating in the flow pipes releases its heat to clients via heat exchangers. The return pipe conveys the water back to the production plant for reheating. The temperature of return water from clients to the production plants ranges in best cases between 25 and 50 °C. The district heating water in general does not circulate in the space heating networks of buildings, but also direct connection variants to consumer equipment exist.

End users equipment

Clients receive the district heat in the substation, which includes the heat exchangers for heating and service water and possibly a heat exchanger also for air conditioning, control devices, pumps, expansion and safety equipment, thermometers and manometers and shut-off valves and energy metering. Substations are industrially manufactured units. Clients acquire their district heating equipment and the related installation work from heating contractors or, as comprehensive deliveries, from district heating suppliers. Heat is used in buildings for space heating, for providing hot tap water and for air conditioning. Also cooling of buildings by using district heating supply water in absorption chillers has been introduced lately.

Heat metering

The amount of heat consumed in the building is measured. The components of the heat meter are: a flow sensor, a temperature sensor pair, and a calculator. The flow sensor measures the volume of circulating district heating water. The temperature sensor pair constantly measures the temperatures of water going into the building and coming out of the building. Based on the readings of the flow sensor and the temperature sensor pair, the calculator calculates the thermal energy used for space heating and for hot service water. The calculator automatically takes into account the water density and specific heat corresponding to the temperature. The heat consumed is shown by the calculator as megawatt-hours (MWh).

Fig. 3.14: Metering device (CENERGIA).

Reliability

Supply of district heat is very reliable. On an average, in large DH-systems operation interruptions resulting from damages in the district heat network and the consequent repair work leave the individual client without heat as an average for only one hour a year. Thus, the reliability of supply in district heating is nearly 100%. District heating is also operation and maintenance free for clients – as the maintenance is included in the fee paid by the clients.

Potentials for development of district heating systems

Increased temperature difference/ low temperature systems: At low and medium load times a high temperature difference is desirable because it can save pumping energy and in many cases can reduce distribution heat losses. Low return temperatures improve also operating conditions and efficiency of CHP.

Heat driven district cooling

In a cold climate there are in summer months plenty of heating capacity available in district heating systems, e.g. for heat-driven cooling. The research issues are how the present one stage water/LiBr absorption process is operated with low temperature district heat. Another problem is the hydraulic restriction of maximum water flow in existing district heating transmission pipelines. The heating demand at wintertime limits the cooling load produced by absorption chillers to about 20% of wintertime maximum load. In warm climate the annual electric power peak occurs in summer, partly due to electric air-conditioning and refrigeration. If a part of the air-conditioning cooling demand would be covered with heat driven cooling machines, the power peak would be shaved off.

Incorporation of solar energy storage

Solar district heating with short-term and seasonal storage have been introduced, mostly in Denmark and Germany. Short-term storage systems are used mainly for the preparation of hot water and able to store heat for one or two days. Therefore the solar fraction of the total heat demand is limited to about 10-20%. The so called week storage system has relatively large collector area per living area (4-10 m^2/m^2) and projected solar fraction 30-40%. An innovative solar–district heating system called pulse heating has several buffer tanks connected to solar panels and district heating network. The buffer tanks are heated by solar energy with district heating as backup. One tank in turn is filled with hot DH-water as a pulse and other times the DH circuit is closed for reduced pipe losses. The first experiences call for remarkably reduced heat losses and 40-70% annual solar fraction.

District heating systems with low losses are used the in the following Best Practice Examples mentioned in Chapter 5: no. 1 and 8 from Austria and no. 7 from France.

3.2.8 Combined heat and power

Combined heat and power (CHP), often referred as co-generation, is the joint production of heat (steam or hot water) and electricity from a single fuel source, which can result in the overall efficiency up to 70 – 90%. Some CHP systems produces also chilled water from the heat. This is often called tri-generation. Conventional electricity production plants convert about 30 to 40% of fuel energy into electricity, while the rest is lost as waste heat.

Combined heat and power systems can be implemented on many different levels. At the largest scale, utility heat production can cover a whole city through a district heating system and generated power is supplied into national electricity grid. Large scale CHP installations, typically hundreds of MWth and MWe, are found in process industry and in district heating of large cities, mainly in northern Europe. Small-scale CHP installations, typically below 1 MWe and installed within the buildings that they serve, are relative common in the middle and south Europe. Dimensioning of the CHP plat will be made according to the heating load. The electricity output will be used first in house and secondly sold to the electricity grid.

Power-generation technologies, which can be applied in small scale CHP systems, include advanced turbine systems, reciprocating engines (Otto and Diesel), micro turbines and fuel cells.

In large scale CHP systems back-pressure turbines, gas turbines and diesel engines are typically used in power generation. Practical uses for co-generated thermal energy include process heating, space heating, water heating, absorption chillers, engine driven chillers, desiccant dehumification, compressed air and industrial processes. In traditional CHP/DH plants heat is extracted from major power plants and supplied to city district heating networks or for industrial use.

In Best Practice Example no. 4 from Bulgaria in Chapter 5 combined heat and power are being used.

3.2.9 Heat pumps

Heat pumps are used for transforming free heat from sustainable sources: air, water, ground and waste heat, to useful temperature level. They are used for residential and commercial rooms for heating, cooling and domestic hot water heating as well. A high number of different heat pumps exist and they vary in size, price and efficiency depending on its purpose.

Heat pumps for heating and cooling purposes in buildings can be divided into four main categories depending on their operational function:

- Heating-only heat pumps, providing space heating and/or water heating.
- Heating and cooling heat pumps, providing both space heating and cooling.
- Integrated heat pump systems, providing space heating, cooling, water heating and sometimes exhaust air heat recovery.
- Heat pump water heaters, fully dedicated to water heating.

It is considered that using heat pumps can significantly reduce CO_2 emissions. In some European Countries heat pumps are treated as a renewable energy source. This allows obtaining some donation from environmental funding. A heat pump does not require chimneys or gas or oil installations, and it does not produce any pollutions or wastes.

The heat pump is a machine, which can change heat from a low level of temperature to a higher one. As a low level temperature heat source the following are usually used: ground (vertical or horizontal heat exchangers), ground and surface water (open or close loop), outdoor and exhaust air. A good idea may be to use waste heat as a low temperature heat source, where the heat is transformed to a higher level of temperature by a compressor. The heat sink is usually a central heating system or/and domestic hot water. It is also possible to make a reversible operation with the heat pump in cooling mode.

Below are shown two kinds of heat pumps: heat pump using heat from the ground and a heat pump using heat from the outside air. The last mentioned are popular in holiday cottages and patios. The one shown on the picture is connected to a small PV-plant producing the necessary electricity for running the pump.

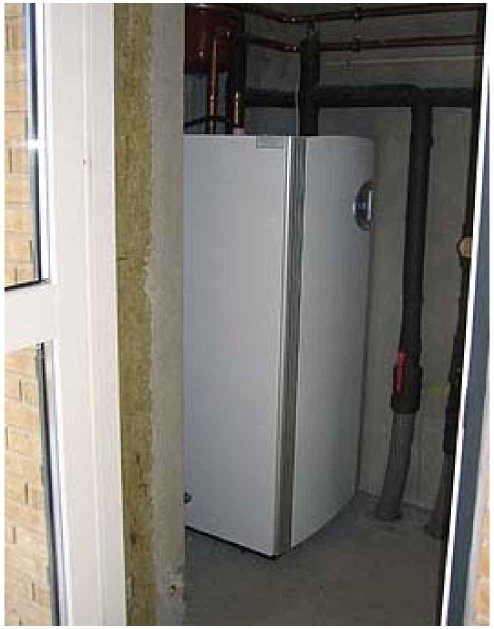


Fig. 3.15: Heat pump producing heat for 8 apartments using heat from the ground (CENERGIA).

Fig. 3.16: Heat pump using heat from the air and connected to a small pv-plant which produces the needed electricity for running the pump (CENERGIA).

In the heating mode, the external fluid returns from the ground and passes through the heat exchanger. Within the heat exchanger the internal fluid is allowed to expand and change state into a gas (vaporization) drawing the heat of vaporization from the external fluid. This gaseous fluid is then pumped to the compressor which compresses and liquefies the fluid releasing the heat of vaporization into the heat sink (heating system, domestic hot water etc.). The cooled external fluid is then pumped back into the pipes running outside the house, where its temperature is lower than the temperature of the surrounding soil. It once again absorbs the heat from the ground and the cycle repeats.

In the cooling mode, indoor air is drawn through a heat exchanger where the internal fluid is allowed to expand and evaporate absorbing the heat of vaporization from the air. The gaseous fluid is then pumped to the compressor where it is compressed back into a liquid releasing the heat of vaporization into the external pipes via a second heat exchanger. The fluid in the external pipes is then pumped out into the heat field where its temperature is higher than the temperature of the surrounding soil. The soil absorbs the heat and the cooled fluid returns to the house to repeat the cycle.

Nowadays there are also heat pumps with direct evaporation and accumulation in a vertical tank. This can reduce the number of heat exchangers, pipe's connections and length of installation. This type of heat pumps usually consume less energy for pumps and compressors, gives heat at higher temperature level and because of less cost became quite popular especially in single family houses.

It can be formulated following limitation in heat pomp using:

- Because a heat pump operates most effectively when the temperature difference between the heat source and heat sink (distribution system) is small, the heat distribution temperature for space heating heat pumps should be kept as low as possible during the heating season. For example replacing conventional radiators (60/50°C)

with floor heating (35/30°C) may increase COP from 2.5 to 4.0. For more information see description of technology B.12. Low Temperature Heating System.

- It is quite difficult to control working of heat pumps. In most cases it is possible only on/off king of control strategy. This is the reason for additional requirements for central heating and/or domestic hot water systems.
- Continuous access to low level temperature heat source should be provided. In some cases it may be difficult (large ground area for horizontal ground heat exchanger, lack of pond, river or lake) or expensive (cost of energy consumption of ground water pump, cost of constructing low level temperature heat exchanger).

Refrigerants should have as low environmental impact as possible - ozone depletion and global warm potential.

<u>COP coefficient</u>

The heat delivered by a heat pump is theoretically the sum of the heat extracted from the heat source and the energy needed to transform the heat from low temperature level to higher one. The steady-state performance of an electric compression heat pump at a given set of temperature conditions is referred to as the coefficient of performance (COP). It is defined as the ratio of heat delivered by the heat pump and the electricity supplied to the compressor (‘how much energy is produced by using one amount (kWh) of energy). The COP of a heat pump is closely related to the difference between the temperature of the heat source and the output temperature of the heat pump. The COP drops with the increasing of condensation temperature.

As the heat pump uses electricity it might be necessary also to take into account the amount of energy used for producing the electricity. With a factor 2,3 used for the production of electricity a heat pump with a COP of 3,0 will have a resulting energy efficiency of 1,2 (3,0/2,5). This is an important aspect to consider when calculating the energy efficiency of the house and might be demanded by implementation of EPBD.

The COP of an ideal heat pump is determined by the condensation temperature and the difference between condensation and evaporation temperature. The ratio of the actual COP of a heat pump and the ideal COP is defined as the Carnot-efficiency. The Carnot-efficiency varies from 0.30 to 0.5 for small electric heat pumps and 0.5 to 0.7 for large, very efficient electric heat pump systems.

<u>Performance</u>

The operating performance of an electric heat pump during the season is called the seasonal performance factor (SPF). It is defined as the ratio of the heat delivered and the total energy supplied over the season. It takes into account the variable heating and/or cooling demands, the variable heat source and difference in sink temperatures over year, and includes the energy demand, for example, for defrosting. The SPF can be used for comparing heat pumps with conventional heating systems (e.g. boilers), with regards to primary energy saving and reduced CO_2 emissions. However SPF is very useful in practice it is quite difficult to obtain.

The performance of heat pumps is affected by a large number of factors. For heat pumps in buildings these include:

- the climate - annual heating and cooling demand and maximum peak loads;
- the temperatures of the heat source and heat distribution system;
- the auxiliary energy consumption (pumps, fans, supplementary heat for bivalent system etc.);
- the technical standard of the heat pump;
- the sizing of the heat pump in relation to the heat demand and the operating characteristics of the heat pump;
- the heat pump control system.

3.2.10 Natural, hybrid and PV-assisted ventilation

With the high demands for ventilation systems, there is a great need for energy efficient ventilation systems. In connection with this natural, hybrid and PV-assisted ventilation systems are very interesting topics.

A Danish research project has shown that natural ventilation can be environmental correct and safe working and also be a good solution

regarding indoor climate. The analyses show that natural ventilation can be sufficient as ventilation in e.g. row houses, if the design and function of building is integrated in an architectural way that optimises the natural ventilation. Benefits of natural ventilation are listed below:

- Provides effective whole house ventilation
- Reduced CO_2 emissions and lower fuel bills
- Combats condensation and mould growth
- Continuous gentle extraction
- Improved acoustic quality, < 25dBA, compared to mechanical ventilation
- Simple installation
- Unobtrusive
- Minimal maintenance

The most optimal solution for natural ventilation is where all rooms are located on the same side in a row house. In this way the ventilation will be dominated by thermal buoyancy because the outdoor air will enter through the windows to the rooms on south side, and exit through a tall chimney element on north side that has outlet from kitchen and bath room.

In an energy efficient demonstration project of a public school, Egebjerg School, in Ballerup in Denmark natural ventilation has been used. The implemented technologies connected with natural ventilation are:

- Advanced EMS-system with control of heat, ventilation and lighting.
- Combined use of natural and mechanical ventilation.
- Pre-heating of ventilation air through channels in ground and through a so called Canadian Solar Wall (with small holes for air inlet) and convectors in class rooms.

In the centre of the area that was chosen for renovation there is a space with double height compared with the rest of the building and on the roof of this space a ventilation chimney has been placed for natural ventilation. The primary drive force is the wind pressure. By help of an EMS-system the windows in ventilation chimneys can be opened in lee side. If there is no wind at all thermal drive forces are activated. The height is therefore an important factor. When the temperature difference between inside and outside in summer times is very low an absorber built in the ventilation chimney provides the necessary drive pressure. The amount of ventilation is controlled on background of CO_2- and temperature sensors in class rooms.

The heat consumption with pre-heating of ventilation air is 97 kWh/m^2, and was 181 kWh/m^2 before the renovation and users are very satisfied with the improved indoor air climate.

The electricity saving with natural ventilation, electricity efficient ventilation and EMS control is 13,5 kWh/m^2 per year. Before renovation the electricity consumption was 36 kWh/m^2 per year. Also indoor air climate has been improved and the amount of CO_2 is satisfying.[1]

Regarding PV-assisted ventilation PV-VENT system has been developed. PV-VENT combines building integrated PV with high effective ventilation systems. The PV produces direct current (DC) which can run low consuming DC-engines in a new generation of effective counter flow heat exchanger. In this way energy loss and an expensive converter installation can be avoided.

Counter flow exchanger is run with an electricity consumption of only 20-30 W, equal to 150-200 kWh per year. 25-50 % of this electricity consumption can be covered by electricity from building integrated PV. Oriented to south an optimal PV area is assumed to be 0,7 m^2 per dwelling for crystalline panels and 2 m^2 per dwelling for amorphous panels.
The ventilation system in a PV-VENT system shall be with low electricity consumption with counter flow heat recovery, where the outlet air is used for preheating of the inlet air. The heat recovery of outlet air shall be 80-90 %. The electricity consumption is as low as 20-40 W per dwelling.

Fig. 3.17: PV-assisted solar ventilation towers and PV-chimney were PV modules are directly operating DC-fans (CENERGIA).

PV-assisted ventilation is also used in the Best Practice Example no. 4 from Denmark, mentioned in Chapter 5.

3.2.11 Solar domestic hot water heating system

The European solar thermal market has shown substantial growth over the past decade, with solar collector sales amounting to about 2 million m^2 in 2005 (the total number of installed m^2 was in 2004 about 16 million and the EU target for 2010 is a total of 100 million m^2 (Estif 2005)). However, Germany, Greece and Austria account for 80% of the collector area in operation throughout Europe. When the glazed collector area is related to the population, the leading roles of Austria (about 275 m^2 per 1.000 capita) and Greece (about 270 m^2 per 1.000 capita) becomes even more evident, compared with the EU average of 24 m^2 (Estif 2006). In recent years the market for solar domestic hot water systems in Spain, Italy and France has been growing faster than the EU average, but the market is still largely dominated by the strength of the market in Germany (Estif 2005).

Solar DHW systems can be successfully implemented at all latitudes. Some of the strongest markets (Germany, Austria) are not situated in particularly sunny regions, whereas for instance Spain and Italy are clearly lagging behind. Factors like general awareness of the environment; public support and the quality of the products/services offered by the industry have proven to be at least as important as climatic conditions. The potential for growth in the near future is therefore immense.

Fig. 3.18: Example of installation of domestic hot water heating system at single family house (ECN)

The functionality of a solar system is a result of two factors: the quality of its components (collectors, tank, control units etc.) and the quality of the system design and installation.

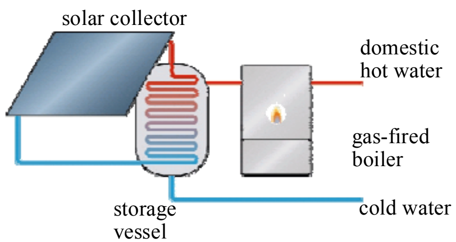


Fig. 3.19: Example of domestic hot water heating system (ECN).

Solar collectors can also be used for space heating water. This kind of system is mainly used in the northern and central part of Europe: In Austria they have a market share of 35% (Estif 2005).

Solar DHW heating systems are used in Best Practice Examples no. 11 from Austria, no. 1 from Denmark, no. 1 from Sweden and no. 7 from France.

3.2.12 Solar wall and air collectors

The potential energy saving of an air solar wall are very high because the collector enables the active solar heating of the ventilation air while minimizing heat losses by transmission through the south wall.

The Canadian "Solarwall" type air solar collector consists in a metallic outdoor surface placed in front of a heavy masonry wall that acts as an accumulator.

Fig. 3.20: Example of a Canadian Solar wall at a factory building (CENERGIA).

The air between the metallic wall and the masonry gets warmer and is distributed in the building in various ways, directly or through a classical ventilation system. Other types of air solar collector are e.g. based on the "Trombe wall" principle, and it consists in a transparent wall, or the air solar collector typically built with one layer of glass, absorber and insulation. These solutions are often more expensive.

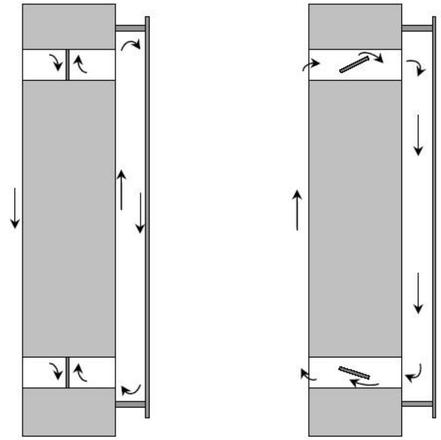


Fig. 3.21: Example of principle of Solar Wall (CENERGIA)

An air solar system, or a solar wall, has an efficiency that varies between 50% and 70% according to the air flux and gives about 700 kWh/m² in a year, in condition of low temperature differences between inside and outside and with high air flow (500 kWh/m² in a year, with high temperature differences and low air flow).
Solar wall and air collectors are used both in residential and industrial building. Since a high level of energy saving is obtained with the use of an air solar collector system, this technology is often used in special buildings as solar or passive houses.

Solar walls are used in the Best Practice Examples no. 1 from Austria, no. 1 and 4 from Denmark, no. 1 from Sweden and no 5 from Switzerland. All mentioned in Chapter 5.

3.2.13 PV-installations

Photovoltaic means the direct transformation of sunlight into electric current. In general, two types of PV-systems can be identified: there are systems with mains connection and isolated operated systems and these

are the type of PV-systems standing-alone, which means that they have no connection to the public power supply system and therefore need a battery for storage.

Fig. 3. 22: Example of Building integrated photovoltaic (ECN/CENERGIA).

PV installations constitute a long-term and relatively expensive investment. Therefore, it is essential that an exact design of a certain PV installation is carried out.

In order to be able to design a PV installation extensive and precise information of a wide range of parameters are required, e.g. climatic data, characteristics for PV-modules, configuration of PV-panels, placing of PV-panels, load on PV-panels, current inverter data, the wanted electricity production over a year etc.

On basis of this information it will be possible, via a computer and relevant software, with considerable accuracy to simulate the yield of a certain PV installation. Simulations like this can be calculated by knowledge centres and consulting engineers.

The technique of a PV-installation is based on the photovoltaic effect: if light (photons) hits a solar cell, electrons are released out of the crystal structure of the semiconductor material. This process results in a current flow.

The main components of a PV-system are the solar cell, the solar module and the inverter. The solar cell is the part of the installation, in which the transformation of light into electric current takes place. More than 95 per cent of all solar cells that are produced in the world are made of Silicium. In order to get a useful performance, mostly 30 – 36 solar cells are put together to a solar module. The totality of the modules is called solar generator. The tension of the PV-installation depends on the number of modules connected in series, whilst the number of modules connected parallel determines the current intensity.

The inverter creates the connection between the solar generator and the distribution net. As the produced electric is direct current, the inverter has to transfer it to alternating current, in order to deliver it to the public power supply system.

The performance (measured in %) of a PV-installation depends on different factors. These factors are apart from the position, the slope, the orientation, the performance ratio and the efficiency of the inverter.

Estimated actual efficiency of modules (modules with silicon cells)	Standard	High-efficiency
Monocrystalline, close-packed	12%	15%
Polycrystalline, close-packed	10%	13%
Amorphous /thin film	5%	9%

Fig. 3.23: Estimated actual efficiency of modules

The performance ratio is the measure of the system efficiency of the PV-installation. With the help of this factor, PV-systems at different positions can be compared with each other. It is the relation of the actually produced current to the theoretically expected current of the solar generator. The actually produced current is less than the theoretically expected, because it includes occurring losses. The higher the performance ratio of a PV-installation is, the better the proceeds of current will be.

Estimation of system coefficient	Detached	Building integrated
Optimal installation with high-efficient current inverter	0,8	0,75
Average installation with standard current inverter	0,7	0,65
Less optimum installation, e.g. some shadows	0,6	0,55

Fig. 3.24: Estimation of system coefficient

Other factors characteristic of the energetic efficiency of a PV-system are the night-consumption, the energy use in stand-by modus and the input start. All of these factors are measured in Watt (W). The lower these values are the less energy is used by the installation.

PV-systems are used in Best Practice no. 11 from Austria and no. 3 and 4 from Denmark, mentioned in Chapter 5.

3.3 Concepts of renovation

When planning a renovation there are numerous technologies to choose from. Financial aspects, traditions and availability most often decide which technologies are chosen and calculations of energy savings compared to the necessary investments neglected. There are though good incentives to consider the energy aspect especially in a more future oriented and sustainable perspective.

There are no general solutions for concepts of renovations but uses of the technologies mentioned in this chapter are the most common. The extent of the use of the mentioned technologies determines the energy efficiency of the building. One of the best known concepts of low energy houses is the German Passive house concept. Even though the passive house standard does not refer to a renovation concept the passive house elements can be efficient guidelines when planning your renovation. The Passive House concept will be presented in the following.

3.3.1 Passive houses

The term Passive house (or Passivhaus in German) refers to a specific construction standard for residential buildings with good comfort conditions during winter and summer, without traditional heating systems and without active cooling. Typically this includes very good insulation levels, very good air tightness of the building, whilst a good indoor air quality is guaranteed by a mechanical ventilation system with highly efficient heat recovery. Passive house is a quality level for very energy-efficient buildings of all categories. The specific heating demand is lower than 15 kWh/m²a, which means that a 100 m^2 apartment needs no more than the equivalent of 150 litres of oil per year. At the same time a passive house is characterised by an effect demand of only 10 W/m2, which means that heating can be obtained by fresh air heating. Furthermore the thermal comfort and air quality are much higher than in “normal” houses. Since 1991, more than 8.000 passive houses have been realized in many European countries. The principles of the passive house concept are the following:

Minimized transmission losses

Heat, that is kept inside the house need not be replaced by using energy – this is the most important passive house principle. For this reason the building envelope has a very high standard of insulation – typical thicknesses for wall and roof are around 30 to 40 cm. Typical windows will be triple-glazed.

In Passive Houses it is also very important to avoid cold bridges and there must be kept warm surfaces of the walls also in corners and at joints.

Minimized ventilation losses
In Passive Houses it is necessary to use ventilation with balanced counter flow heat recovery as described in 3.2.5. To reach a sufficient low energy standard it is though very important to use one of the most efficient ventilation heat exchangers in combination with fans which are very efficient. The fresh, filtered air is always more than 17,5°C warm. An important precondition is that the infiltration losses are reduced as well. For this reason, the envelope needs an excellent air-tightness equal to 0,6 /h at 50 Pa (see 3.2.3 about air-tightness).

The air-tightness is also important because HRV is used in Passive Houses and the change of air therefore must be controlled. It is important to remember that air-tightness is not the same as diffusion tightness – gypsum wallboards are airtight but not diffusion tight. Also many insulation materials are not airtight and are not supposed to be and the air-tightness are secured in another way. When building an airtight construction it is important to check if the building reaches the planned goal. This is done with a Blower door test as describes in 3.2.3.

Passive and active solar
The lower the heat losses, the higher the percentage of passive solar energy. In passive houses, the share of passive solar energy can be 50% or more of the heating supply. Although passive solar is of importance, examples show, that even houses of an energetically unfavourable orientation can reach passive house standard. In addition to passive solar gains, active systems like thermal collectors or PV-systems can be used. The use of solar heat is not necessary to get a Passive House certificate (from the German Passivhaus Institute) but it might be an efficient heating supply.

Efficient energy supply
Passive houses have a very low heating demand but still need a heating system and a system providing domestic hot water. In order to minimize energy demand and costs as well as the emission of pollutants, the energy demand of passive houses is supplied by very efficient systems like special heat pumps, solar energy, high efficiency gas boilers or pellet boilers.

Overheating control
As a very high thermal comfort was one of the main goals in the development of passive houses, overheating control is an important measure. Passive houses are optimized in a way that reduces overheating problems to a minimum. Mainly passive measures like shading devices, thermal mass and natural (nocturnal) ventilation are used. As mentioned the passive houses does not only has advantages related to the low energy use but also the following aspects cam be mentioned:

Thermal comfort
Inhabitants describe both winter and summer thermal comfort as much better, than in normal houses. Passive house retrofit is about energy saving – but the perfect thermal comfort is what counts most for tenants!

Air quality and health
Comfort ventilation gives tenants a very good air quality. The constant air renewal reduces odours as well as harmful pollutants. Cold bridge minimization and good air tightness avoid mould damages. It is though important not to reach temperatures below 13,1 C to avoid fungi's.

Low energy costs - good funding
Nobody knows the future oil or gas costs - a heating demand of only 1/10 is the best insurance against rising prices. In many countries good funding makes passive house retrofit even more feasible.
The primary energy use can not be higher that 120 kWh/m^2.

Protection of construction
By using thermal insulation, construction is protected and lasts longer. Minimisation of cold bridges and improved air tightness reduces structural damages.

Sustainable building
As PHR-buildings fulfil not only actual but also future requirements, their value will be constant over a long period.

Climate protection – conservation of resources
Passive house retrofit reduces emissions of climate-changing gases and all other polluting gases to less than 10% of the actual state. Natural resources like oil and gas are conserved as passive houses save up to 90% of heating energy.

In the Best Practice Examples which can be found on the homepage – and some in this Chapter 5 example of a passive house renovated building can be found. In Chapter 5 it regards the Austrian example from Linz and at the homepage an example from Germany can be found. See pictures below.

Fig. 3.25: The social housing in Ludwigshafen. Notice the solar cells on the roof and on the balconies.

Fig. 3.26: Examples of thick insulation layer on the façade exterior and new ventilation system (ECN).

References and additional reading

Pedersen 2002: Peder Vejsig Pedersen, Solar Energy and Urban Ecology, Ingeniøren|Bøger, 2002

Estif 2005: European Solar Thermal Industry Federation: "Solar Thermal Markets in Europe – Trends and market statistics 2004", June 2005

Estif 2006: European Solar Thermal Industry Federation: "Solar Thermal Markets in Europe – Trends and market statistics 2005", June 2006

www.estif.org - European Solar Thermal Industry Federation

Text about passive houses: http://www.energieinstitut.at/retrofit/

4. Checklists & tools

4.1. Introduction

In planning of social housing renovation there is a need for a reliable method for selection of the most convenient refurbishment scenario. The guidebook aims at identification of checklists and tools applicable for social housing companies and their consultants when prioritizing the concrete refurbishment projects.

The checklists are used to support the decision making on a general level and at the initial stage of planning process. The checklists are useful also in the procurement process and in design competitions, where the evaluation criteria are needed.

The tools are intended to support further steps of refurbishment measures planning. Although the project teams responsible for planning the building renovation aim at a tool that would support technical, economic and environmental evaluation of refurbishment scenario, there is a lack of such complete tools. More often the tools have to be combined in order to get the complete view about the renovation project.

All checklists and tools can be found on the website:
http://ei-education.aarch.dk

4.2. Steps to successful renovation

The renovation will not be successful unless the existing administrative and practical barriers are taken into consideration. An overall screening and analysis is necessary as well as knowledge of the existing technological possibilities. The analysis also implies establishing the potentials of the housing regarding various factors such as its suitability for housing seniors, the quality of its surroundings, if the sizes of the apartments appeal to certain kind of groups etc. These potentials are important to consider as they are decisive for the tenants acceptance of the energy aspects.

Regarding possibilities of energy efficient renovation the following steps are necessary for a holistic approach:

- Inventory of building condition and technical assessment of building components
- List of measures / investments necessary that are necessary for the building to further comply with 6 essential requirements (mechanical resistance and stability, safety in case of fire, hygiene, health and the environment, safety in use, protection against noise, energy saving and heat retention); the investments are necessary for maintenance of the original building condition
- Analysis of energy costs and energy use – identification of energy saving potential
- Energy audit including economic evaluation of RES and RUE measures, feasibility study, if needed
- Definition of the targets of building renovation (improvement of thermal comfort, prolongation of the building life time, low energy building, passive house standard refurbishment, increased value of the building …)
- Evaluation of refurbishment scenarios; methods: life cycle costing (LCC), LCA, social acceptance…
- Definition of an action plan – list of renovation measures including EE measures and other necessary investments for renovation of a social housing
- Design phase
- Tendering procedure, investigation of financing instruments
- Investment
- Commissioning
- Monitoring and evaluation of investment
- Promotion of goods results

4.3. Checklists

The checklists define the indicators for evaluation of the project and aggregate them to the level convenient and understandable for decision making. The indicators for the evaluation of refurbishment projects are usually weighted according to the local framework conditions relevant for housing association decision making.

The checklists are the following:

- 4.3.1 Simple evaluation of refurbishment scenarios
- 4.3.2 Evaluation of energy management in housing companies
- 4.3.3 Evaluation of renovation scenario by sust. indicators
- 4.3.4 Energy performance demands / Green Catalogue
- 4.3.5 Additional examples of checklists from the literature

4.3.1 Checklist for simple evaluation of refurbishment scenarios

A checklist for simple evaluation of refurbishment scenarios is useful at an early stage of the planning process, when the concepts are defined. It is prepared for the use of evaluation of different refurbishment scenarios. En example can be seen below. Proposals are evaluated according to six indicators, each of the indicators is ranked in a range between -2 to +2 points, where 0 points represent neutral impact of the proposal to the particular indicator, -2 points represent major inconsistencies with the targets and +2 points indicate well elaborated proposal, proving the accomplishment of particular indicator's targets.

In the Fig. 4.2 there is an example of simple evaluation criteria for the comparison of energy efficiency renovation projects, such criteria can be used in the evaluation of design in the framework of architectural competition.

PROJECT	DECISION MAKING INDICATORS OF RENOVATION PROJECT	Ranking				
Indicator r	Value	-2	-1	0	+1	+2
1	Environmental performance				1	
2	Investment costs of renovation project		-1	0		
3	Economic evaluation of energy efficiency investment (PB, NPV, LCC)				+1	
4	Additional living space			0		
5	Improved quality of life in a renovated house and/or neighbourhood				+1	
6	Other criteria, like: easy maitenance, social acceptance etc ,					2
Σ	4	0	-1	0	3	2

Figure 4.1. Checklists with indicators for evaluation of different renovation scenarios in the early stage of the planning process with and example of ranking.

221113	**Energy efficiency of building refurbishment**					
1	implementation of architectural principles in EE renovation: principles of passive solar architecture, bioclimatic buildings, zoning of rooms ...		-1			
2	renovation design takes into account insolation and shading benefits resulting from urban planning concept			0		
3	high level of thermal insulation of building envelope, energy efficient windows and doors, systematic prevention of thermal bridges, calculation and proofs, certificates (passive house principles, optionally)				1	
4	energy efficient windows, parameters (passive house standard, optionally), shading integrated			0		
5	RES implemented, (heating, domestic hot water…)			0		
6	other issues, technologies relevant for energy efficient renovation (also energy certificate available…)			0		
□	**0**	0	-1	0	1	0

Figure 4.2. An example of simple evaluation criteria for enabling the comparison of energy efficiency renovation projects.

4.3.2 Checklist for evaluation of renovation scenario by sustainability indicators

Sustainable renovation project is expected not only to reduce the environmental burden of the building but also to demonstrate favourable economic parameters and high social acceptance.

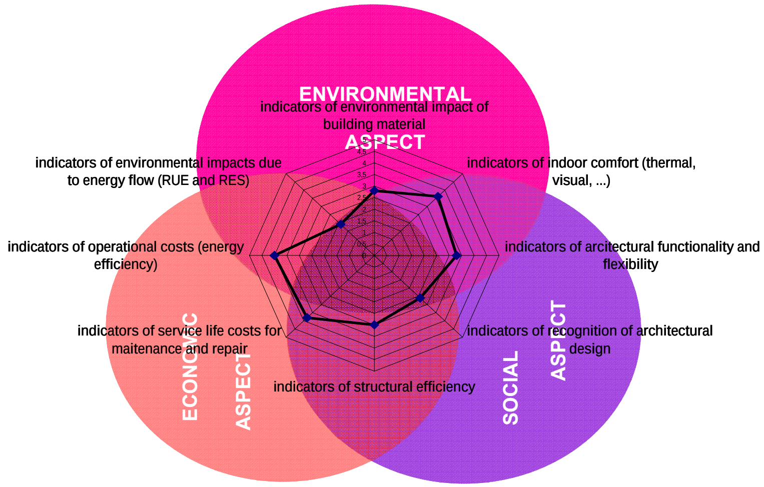


Fig. 4.4 Renovation measures influence environmental, economic and social aspects of building sustainability, aggregated indicators on the axes reflect the acceptance of proposed renovation in the local environment. Successful residential building renovation must positively influence all three aspects.

In the Fig. 5.4 a tool for evaluation of sustainability of an apartment house is presented, developed in the framework of ZKG national quality mark scheme (http://gcs.gi-zrmk.si/gcs/znak.htm). The indicators are aggregated according to the area of impact and presented on eight axes, with relevance to environmental, economic and social aspect of sustainability. A consensus-based method is appropriate for determination of the particular indicator value. An open discourse among the developers (housing association and consultants) and participating stakeholders can be used for the determination of aggregated indicators values and weights. If weighting of indicators is used then a pole among stakeholders in social housing should be used for the identification of their opinion and acceptance of the particular indicator in the local context.

4.3.3 Checklist for evaluation of energy management in housing companies

The checklist below (Fig. 4.3) was developed to help the housing companies to evaluate the quality of the energy management in their own organisations, the capacity to implement the EE renovation project of social housing and to identify the gaps in promotion of energy efficiency in social housing. Thereby it aims at motivating the hosing companies to improve their general policy for renovation of social housings according to contemporary environmental targets in the society.

First of all several sectors given in the checklist are evaluated, according to a prepared description. The level of development in the particular sector is then indicated. The selected cells form a pattern of selected options. The more uniform the pattern of answers is and the higher evaluation notes were allocated, the more developed is the energy management in the housing company.

	Level of development				
Scope	1	2	3	4	5
Energy policy in municipality	No clear energy policy available	General principle of EE in municipalities are known, no written commitment exist, no systematic monitoring of energy consumption on municipal level	The interest in energy efficiency in the municipality exist, the energy use in the municipality is analysed, but there are no major activities (no support for EE renovation of social housing)	An energy policy is defined, occasionally EE measures are implemented / stimulated, based on previous energy analyses	Municipal energy plan available, energy audits and feasibility studies in building sector are common practice, financing instruments for EE investments available
Organization and interest for EE topics in housing companies	No energy management is available in the housing company, there is no formal responsibility appointed to any of employee	Energy management is not introduced, but there are a bottom up initiatives from some individuals employees in h.c. or energy experts are occasionally subcontracted to cover the needs	H.c. has energy manager, but his authority is unclear in the management structure of h.c.	Energy manager in h.c. has clear responsibility, but the energy issues have not yet the highest priority in the investment policy	Energy manager in h,c, has a fully integrated role in the management structure, Energy manager is encourage to play a proactive role in planning of investments and refurbishment in accordance to the general RES and RUE targets.
Motivation for EE and awareness raising at clients (residents in social housing)	Social housing tenants work together on EE opportunities and realization of EE projects, they proactively provide initiatives to housing associations for EE renovation	Single representatives of tenants care for EE, including checking and follow up on the energy consumption and bills. Individuals give proposals for EE renovation and improvements to housing companies.	Tenants refer to a housekeeper and/or to a h.c. representative in case of increased energy bills and in case of refurbishment and renovation needs. No concrete proposals are made.	The tenants complain in case of high energy bills and/ or high operational costs	The tenants co-operate with energy managers in identification of energy problems and in proposing the EE measures. Their awareness in RES and RUE topics is high and influences their activities and habits.
Monitoring of energy performance and energy use and setting the targets for improved energy situation in social housing	Energy indicators are not monitored.	Energy indicators are monitored, but there is no systematic evaluation of them. There are the data available to set up a data base for benchmarking of energy consumption indicators.	Energy indisubject tocatore are regularly benchmarked as criteria for prioritizing of future refurbishment measures.	Monitored data are used for benchmarking and for instant reaction to identify missfuctioning of buildings and energy systems, respectively. Large energy consumers are subject to energy audit and further renovation.	Energy indicators collected by regular monitoring of energy consumption are used to create a reliable benchmarking data base, Data are used for setting the targets for new buildings and renovation, for evaluation of investments
Promotion of RES and RUE targets, technologies and approaches in social housing and in housing company.	No promotion of RES and RUE targets.	RES and RUE are discussed within housing company.	RES and RUE programmes in h.c. developed, mainly used in planning of refurbishment measures.	RES and RUE promotion activities for tenants developed, no proper response achieved.	RES and RUE promotion is well established, so that a proactive response from tenants is achieved. User habits have been improved.
Status of Investment in EE renovation of social housing	No investment in EE renovation, due to other priorities and mainly financial barriers.	Only low cost measures are implemented.	EE measures with low pay back time are realised.	EE measures are considered within regular plan of building maintenance and refurbishment, often on a basis of energy audit.	EE measures are implemented also on the basis of environmental targets, as a part of a comprehensive h.c. policy for social housing renovation.

h.a. – housing association, h.c. – housing company, s.h. – social housing, EE – energy efficiency

Fig. 4.3 Checklist for evaluation of energy management in housing companies

4.3.4 Energy performance demands based on the Green Catalogue

Energy performance demands for seven different building related technologies can be used both as a guiding tool and as a checklist to see how good chosen technologies are compared both to different national standards. For each of the best practice technologies like insulation, low energy windows, heat recovery ventilation, solar DHW heating etc., a number of indicators and performance requirements/recommendations have been agreed both on a national and European basis.

In connection to this identification has been made on both reference values. (REF) and values for best available technologies (BAT) (which is the best), as well as aimed at values for 2006 (new EPD demands) and 2011 (revised EPD demands after 5 years).

The most important technologies in the area of Rational Use of Energy (RUE) and Renewable Energy Systems (RES) in buildings are:

1. Insulation
2. Low-energy Windows
3. Air-tight Constructions
4. Heat Recovery Ventilation with Low Electricity Use
5. Natural, Hybrid and PV-assisted Ventilation
6. Solar DHW Heating System
7. PV-installations

For examples of the mentioned indicator sheets see the project homepage: http://ei-education.aarch.dk

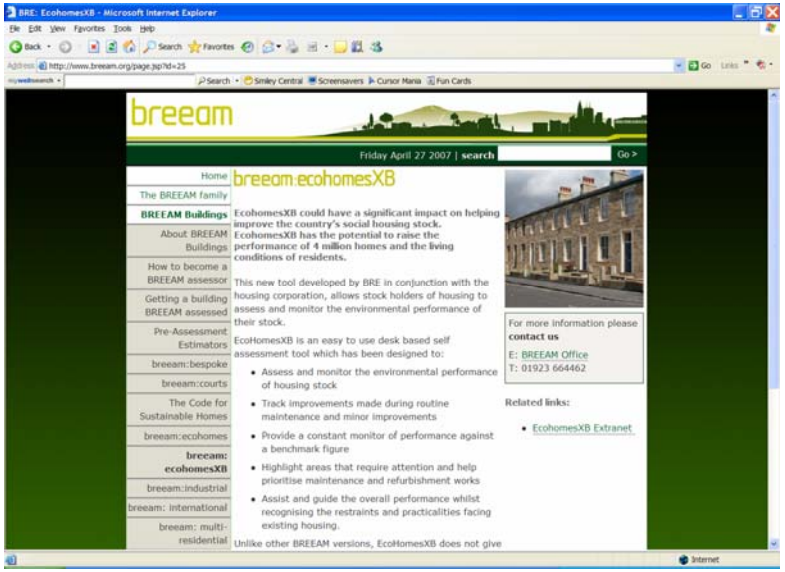
4.4. Tools

In the following an overview are given on a selected number of tools.

EPIQR

Scope: Decision aid tool for residential building refurbishment
Link: Dominique Caccavelli, CSTB, France (caccavelli@cstb.fr)
Author(s): European project EPIQR (Joule programme)
Language: English, French, German
Availability of tools: public / demo / professional
Level of analysis: technical diagnosis, energy performance, indoor environment quality, cost of works
Profile of the expert working with the tool: technicians
Relevance to housing companies and refurbishment of social housing: high

BREEAM EcohomesXB



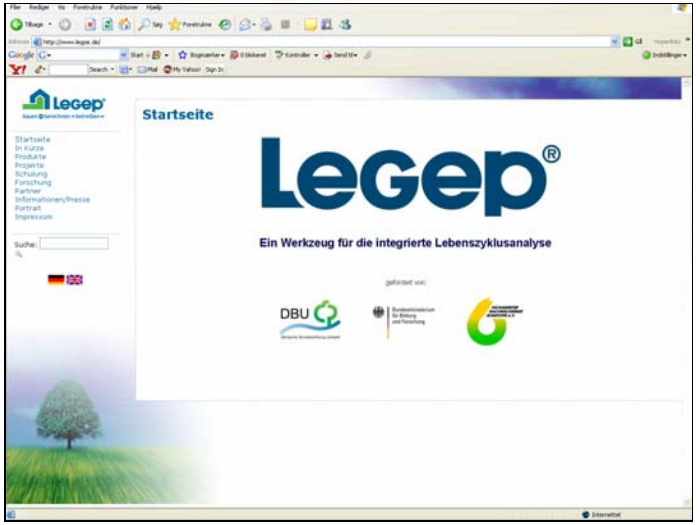
Scope: Tool for housing associations and stock holders for assessment and monitoring the environmental performance of their stock, including the help in prioritising maintenance and refurbishment works.
Link: http://www.breeam.org/page.jsp?id=25,
Author(s): BRE Building Research Establishment, UK
Language: English
Availability of tools: professional
Level of analysis: environmental performance, tracking of improvements during maintenance, benchmarking of performance, highlighting priorities for maintenance and refurbishment
Profile of the expert working with the tool: professionals at housing companies
Relevance to housing companies and refurbishment of social housing: high

Green Diploma

Logo from the Green Diploma for housing estates

Scope: The Green Diploma Labelling can be used to promote improved energy saving standards including use of the Danish low energy class 2 even for large scale renovation. The Green Diploma consists of a table that has to be filled out, by the housing company, the owners, the builders – or extern consultants. See the table in Annex 2. The table make it possible to compare the following standards: A: Minimum EPBD demands for renovation in Denmark (without energy frame values), and B: Green Diploma quality where low energy class 2 is the demand for large scale renovation projects which affects the whole building.
Link: The Green Diploma has no internet page. See tables in Annex 2. Green Diploma Manual (can be downloaded in Danish from DCUE´s homepage, http://dcue.dynamicweb.dk/Default.asp?ID=22)
Author(s): Danish Housing Associations in co-operation with the Cooperation of Housing Associations, BL, Cenergia Energy Consultants and environmental manager Bettina Fellow
Language: Danish and English
Availability of tools: public / demo / professionals
Level of analysis: Profile of the expert working with the tool: experts, engineers, architects
Relevance to housing companies and refurbishment of social housing: high

LEGEP

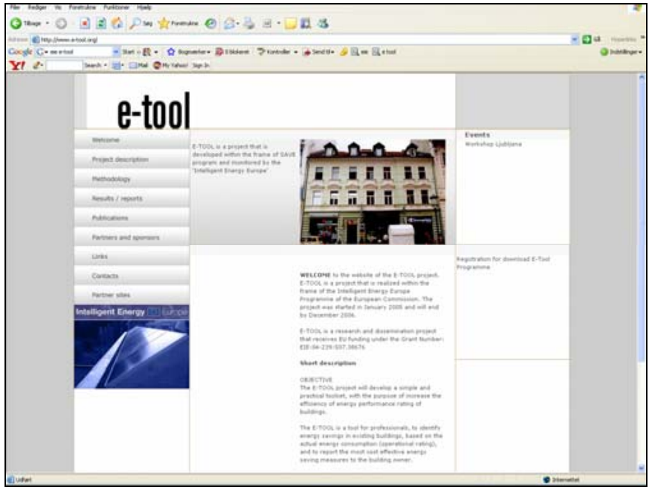


Scope: An integrated life cycle analysis tool
Link: http://www.legoe.de/
Author(s): LEGEP Software GmbH
Language: German
Availability of tools: public / demo / professionals
Level of analysis: complete technical analysis, energy calculation, calculation of investment LCC, environmental impacts
Profile of the expert working with the tool: experts, engineers, architects
Relevance to housing companies and refurbishment of social housing: high

LC-Profit

Scope: A tool for life cycle costs analysis of new building or refurbishment, from the investors and building owners viewpoint.
Link: http://www.lcprofit.com
Author(s): Statsbygg, Norway, now SINTEF
Language: English
Availability of tools: public / demo / professionals
Level of analysis: Investment, service-life, energy costs, maintenance and refurbishment costs are requested as input. Refurbishment scenarios have to be analysed using another tool in order to determine the input for LC Profit. The tool can be used for all kinds of buildings. The user must provide the data about building elements and costs relevant for design, (re)construction and operation phase. The input covers lifetime of elements, frequency of repair and related costs in construction and operation phase of the building lifetime.
Profile of the expert working with the tool: experts, engineers
Relevance to housing companies and refurbishment of social housing: high

E-Tool



Scope: to identify energy savings in existing buildings based on the actual energy consumption (operational rating) and to report the most effective saving measures to the building owner
Link: www.e-tool.org
Author(s): CENER, Spain in frame of EIE E-TOOL project
Language: English
Availability of tool: professional – can be downloaded for free from the E-Tool homepage, only a registration is required.
Level of analysis: the tool is based on the operational rating method. The main issues are to obtain the energy consumption data and building and systems characteristics. The tool analyses the heating and cooling systems, the water supplying system, the lighting, and the elements of the building envelope. Based on the suggested renovation measures the energy savings and pay-back times for suggested investments are estimated in order to help the experts to make scenarios for renovation.
Profile of the experts working with the tool: professional experts
Relevance to housing companies and refurbishment of social housing: high

4.5 Inspiring tools from other sectors

Since there are not many tools available specifically for social housing renovation, the responsible persons for renovation may use also good examples from other types of buildings; of course minor adaptation might be necessary.

AEDET tool (Achieving Excellence Design Evaluation Toolkit) aims at identification of best practice in design of healthcare centre buildings. The assessor is requested to answer particular questions about the design quality indicator by putting a number in the box (1 being very poor/disagree and 6 being excellent/agree). The topics covered are impact aspect (character in innovation, form and materials, staff and patient environment, urban and social integration), building quality (performance, engineering, construction) and functionality (use, access and space). The AEDET tool is in English and available for free download at:
http://design.dh.gov.uk/content/connections/aedet_evolution.asp .

BREEAM (Building Research Establishment Environmental Assessment Method) is an environmental assessment method for different kind of buildings (multi-residential buildings, housing associations, office buildings, industrial units, retail units, schools and homes (known as EcoHomes). BREEAM method evaluates meeting different environmental targets. The awarded credits are summarised on a certificate indicating performance such as Fair, Good, Very Good, or Excellent. The following areas are covered: management, energy use and emissions, health and well-being, pollution, transport, land use, ecology materials and water consumption. More information on BREEAM is available at BRE website http://www.products.bre.co.uk/breeam/).
Free pre-assessment checklists, available on the BRE Website allow a quick evaluation of the likely rating of a formal BREEAM assessment.

This guidebook emphasises the importance of holistic approach to building renovation, where energy and environmental issues are as important as building functionality and social quality for the building, all these aspects are subject to economic evaluation. Being aware of the need for such approach to renovation many examples of tools of sustainable planning at a larger scale (housing areas, municipal planning) can be useful for housing companies to get inspired when developing their specific approach to building renovation. A comprehensive survey of the evaluation tools for urban sustainability is available in FP5 PETUS project (http://www.petus.eu.com/). The tools focus on different levels relevant for urban sustainability: building component, building, neighbourhood, city and regional level. Learning about various tools for identification of most suitable approach to design and renovation of built environment may create also new ideas in management of existing social housing stock.

References and additional reading

The following projects are also examples of useful tools and checklists

- BREEAM pre-evaluation checklists for multi-residential buildings in case of new design and refurbishment; the topics like management, well being, energy, transport, water, materials, land use & ecology and pollution: http://www.breeam.org/filelibrary/PreAssessmentEstimator_Multi-Res._2006_REV00.pdf

- CIBSE Guide F: Energy efficiency in buildings http://www.cibse.org/index.cfm?go=publications.View&PubID=6&L1=164 http://www.cibse.org/pdfs/GPG207.pdf

- HQE « High Environmental Quality » Quality concept applied the building process

14 targets in 4 families:

F1: Eco construction
F2: Eco management
F3: Comfort
F4: Health

http://www.cstb.fr

- PRIME (Private Investments Move Ecopower) project promotes sustainable energy projects in public buildings and provides checklist for identification of projects.

www.prime-ecopower.net

5. Best practice examples

5.1 Introduction

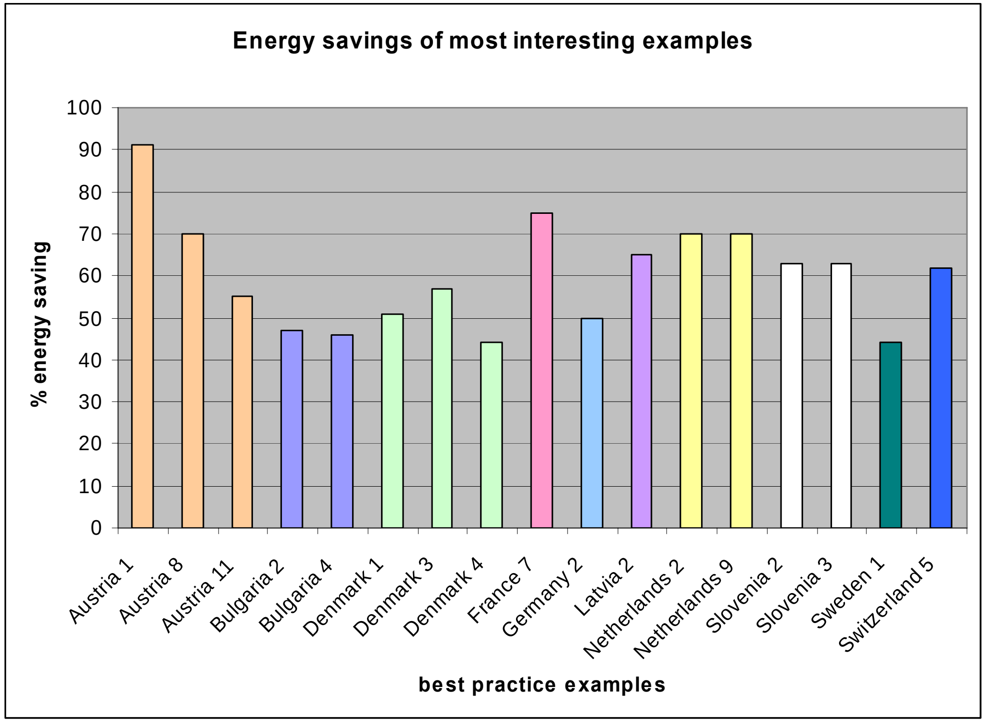
In the frame of this project, the project partners all together collected 60 best practice examples of energy efficient retrofitting of buildings in their region. The best practice examples are all social housing or municipality owned housing for low income groups.

Examples from the following countries have been collected:

- Austria
- Bulgaria
- Denmark
- France
- Germany
- Latvia
- Netherlands
- Slovenia
- Sweden
- Switzerland

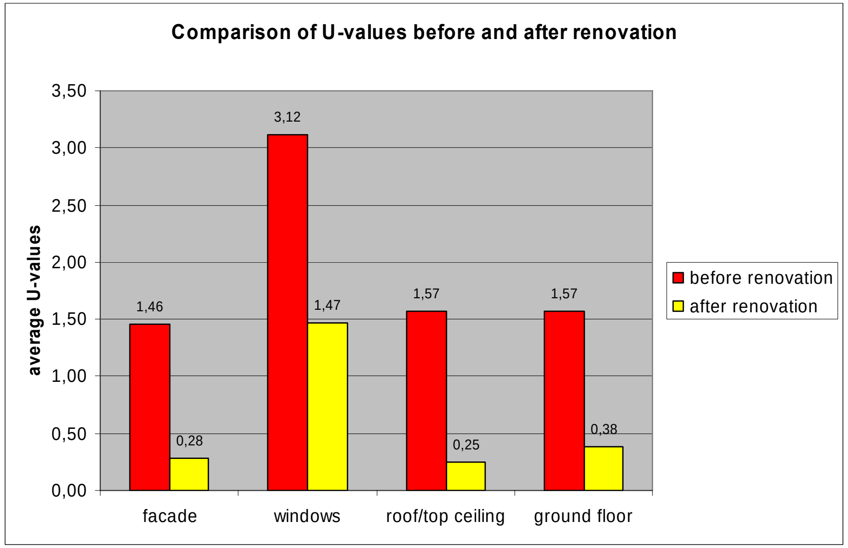
The best practice examples have all performed an increase of energy efficiency of 30 % minimum. Each example shows a comparison between the U-values before and after renovation. To reach the minimum of 30 % energy saving, a comprehensive renovation of the building is usually necessary. This means insulation of the outside walls, the top ceiling, the ground floor and the roof. An exchange of the old by new windows with low-energy glazing and frames goes along with the insulation of the outside walls and is very important for the living quality and the energy standards.

The energy performance indicator before and after is one of the main criteria for the collection and selection of the best practice examples. A high amount of energy saving means a high reduction of fuel and therefore considerably less emissions of CO_2. The following graph shows the percentages of energy savings of the most interesting best practice examples from all regions, ranked by the spelling of the country name. The examples can be seen at the following pages. The numbers refer to the numbers in the database at the website: http://ei-education.aarch.dk



In many cases, the main reason for the tenants to renovate a building is to improve the appearance of the building – to smarten up the house in which they live. Here, an important responsibility falls to the social housing associations, which are supposed to draw the tenants' attention to the need and advantages of a more comprehensive renovation. The advantages are numerous: the conservation of value of the building, the increase of the living quality, the lowering of the heating costs and thus the more efficient use of natural resources.

A comprehensive renovation of a building includes at least the renovation of the facade, the windows, the roof/top ceiling and the ground floor. This means that the building envelope is fully renovated and modernized. A comparison of the U-values of the mentioned parts of the building envelope before and after renovation shows how much energy can be saved by intelligent retrofitting of buildings. This calculation is based on the numbers given in the best practice examples, which are introduced on the next pages.



The graph indicates that the average U-values of façade, roof/top ceiling and ground floor are all improved by around 80 %! The average U-value of the windows could be halved! The insulation of the building envelope and the change of improvement of the windows are some very important measures the save energy in social housing buildings.

The following pages are to provide an overview of the most interesting best practice examples from all regions. The examples are categorized in three groups: Technology & Environment, Organisation & Financing and Policy & Strategy. In each group various examples, which are especially interesting or representative for a region, are briefly presented.

The choice was made on the basis of matrices, which every partner filled in for their best practice examples. By this way, the examples were evaluated by the partner who has collected and written them. Each partner knows the own examples best, has more background-information and can evaluate them better than anyone else. After this first selection, the best practice examples had to be split in the different categories, again by using the matrices and by comparing the different examples. Another criterion in the choice and classification was to have a wide range of best practice examples – so if there were two similar examples fitting in one group, criteria like

- size of the project (number of apartments),
- building typology (detached, semi-detached, row house, low-rise apartment, high-rise apartment) and the
- building environment (urban, semi-urban, rural) helped determining the choice.

To keep track of the presented examples and the different categories, the following tables should help for orientation:

Technology & Environment

This chapter will present best practice examples with special innovative technologies and with a high environmental value (energy savings, usage of renewable energy sources).

The examples presented in this chapter are:

Example	One feature
Austria – Noitzmühle	512 m² thermal solar plant
Austria – Linz	Passive house standard with 91 % energy saving

Denmark – Osterbro	Solar wall construction
Denmark – Lundebjerg	PV modules integrated in façade and roof
Denmark – Sundevedsgade	Heat recovery on ventilation air
France – L'isle d'Abeau	PV for ventilation and low energy lighting in common areas
Germany – Big Heimbau	Solar collectors and solar walls
Switzerland – Lausanne	Ventilation system – air distribution pipes in the first layer of the façade insulation

Policy & Strategy

This chapter deals with best practice examples which pursue an innovative or extraordinary strategy and policy in carrying out the renovation projects.

The examples presented in this chapter are:

Example	One feature
Austria – Steyr	Breakaway of the balconies in an occupied building
Bulgaria – Radomir 2	Pilot project to show possibilities of energy savings in apartment buildings
Netherlands – Raamsdonk	Rent and energy saving guaranty given by housing association
Slovenia – Ljubljana, Hermana	Demonstration project for passive building standard in social housing
Sweden – Göteborg	Sustainable/bio-climate design

Organisation & Financing

The best practice examples presented in this chapter have special interesting solutions concerning the organisation and realisation of the renovation project and/or concerning innovative financial solutions.

The examples presented in this chapter are:

Example	One feature
Bulgaria – Sofia, Zaharna Fabrika	Costs are partly covered by two new rented flats in the attic
Latvia – Kuldiga, Mucenieku names	Good financial scheme
Netherlands – Haarlem	During renovation, tenants moved to "flex-flats".
Slovenia – Ljubljana, Einspiler-jeva	Co-operation of flat owners and their tenants was essential.

Now, the examples mentioned above are presented briefly, first ordered by the three categories and within the categories ordered by the spelling of the country name.

5.2 Technology & Environment

Noitzmühle (Austria)
55 % energy saving **512 m² thermal solar plant** **Reduction of the total living expenses for the tenants**

Objectives and Results

The buildings of "Heimstätte Wels" in the Welser quarter "Alte Noitzmühle" are partly occupied by socially very disadvantaged tenants. For them, the renovation of these buildings and the reduction of the total living expenses achieved by it mean a genuine increase in the quality of life.

The façade and the roof of the buildings were insulated and new windows with a much lower U-value were installed. The energy performance indicator was cut from 87 to 39 kWh/m², a – this means an energy saving of 55 %! Due to the installation of thermal solar collectors (128 m² on each of the 4 buildings), the costs for domestic hot water production were significantly decreased.

Lessons learned and conclusions

- Two years after the renovation of the buildings, an increased satisfaction of the tenants and a larger appreciation regarding the apartments and the buildings could be actually determined.
- Due to the installation of the large thermal solar plants and the insulation of the façade, the energy and water costs were significantly decreased.
- The tenants readily agreed to the renovation measures because they understood that comprehensive renovated buildings mean better life and living quality.

State-of-the-art	
Before renovation	**After renovation**
Constructions [U-values: W/m²K] • Non-insulated roof [0.75] • Non-insulated façades [0.82] • Windows [2.5 – 2.8]	*Constructions [U-values: W/m²K]* • Insulation of roof [0.16] • Insulation of façades [0.24] • Windows [1.60]
Installations • Gas heating system	*Installations* • Exchange of the old gas boiler – now high efficiency condensing gas boiler • 512 m² thermal solar plant (128 m² on each building) • Renewal of all lavatory cisterns due to high losses

For more detailed information, please download the best practice example no. 11 from Austria from the project homepage: http://ei-education.aarch.dk/.

Linz (Austria)

91 % energy saving
Anti-skidding coating of balconies
All tenants are satisfied with the renovation

Objectives and results

The building which is located at a street with very high traffic frequency was in need for renovation – the balconies were nearly unusable because of the heavy traffic resulting in dirt and noise exposure. High energy costs and the wish to do a pilot project to collect experience for other projects also were part of the motivation to renovate an apartment building in passive house standard.

The passive house standard was achieved by a very high insulation of the outside walls by using a so-called "GAP-solar-façade". Insulation of floors and roof as well as triple glazing of windows was necessary for achieving such a high energy standard. In each room a mechanical ventilation system with heat recovery was installed. The energy performance indicator was cut from 179 to 14 kWh/m²,a which is equal to an energy saving of 91 %. The project is very unique and has already received several awards.

Lessons learned

- Already in the first heating period, a time lag in switching on the radiators could be noticed.
- This is one proof that insulation works.
- Calculated costs are always met, if there remain reserves, they are used for additional measures, for example arrangement of the garden and the surroundings.

State-of-the-art

Before renovation	**After renovation**
Constructions [U-values: W/m²K] • Outside walls [1.20] • Roof [0.90] • Cellar ceiling [0.70] • Windows [2.50] *Installations* • Gas boiler	*Constructions [U-values: W/m²K]* • Outside walls [0.08] • Roof [0.09] • Cellar ceiling [0.21] • Triple glazing of windows [0.86] *Installations* • District heating • Mechanical ventilation with heat recovery for each room

For more detailed information, please download the best practice example no. 1 from Austria from the project homepage: http://ei-education.aarch.dk/.

Osterbro (Denmark)

51 % heating saving
Among the most important solar low energy retrofit projects in the housing sector in Denmark
First innovative solar wall construction in Denmark

Objectives and results

The Oesterbro project managed to achieve some good results. The main aim - reducing the district heating consumption and establishing low temperature district heating was succeeded. The indoor air climate was improved by an installation of ventilation systems with heat recovery in all apartments. A 178 m² "solar wall" construction also helped to reduce the energy performance indicator from 125 to 61 kWh/m²,a which is equal to 51 % energy saving.

The project was able to show the possibility of making large energy saving houses with less maintenance costs.

Lessons learned

- Among the most important solar low energy retrofit projects in the housing sector in Denmark

State-of-the-art	
Before renovation	**After renovation**
Constructions [U-values: W/m²K] • Windows with*[4,05]* • Total heating consumption: 125 kWh/m² *Installations* • No mechanical ventilation	*Constructions [U-values: W/m²K]* • Low-energy windows *[1,24]* • Total heating consumption: 61 kWh/m² *Installations* • heat recovery ventilation system

For more detailed information, please download the best practice example no. 1 from Denmark from the project homepage: http://ei-education.aarch.dk/.

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Lundebjerg (Denmark)

Thermal performance ratio: 1,15 per cent
Payback period: 7-8 years
PV production matches electricity use for ventilation
First architectural competition with PV in Denmark

Objectives and results

The objective of this project was to develop low-energy heat recovery ventilation systems which are supplied with electricity from PV modules integrated in the building façade and roof. Calculations show that with PV-ventilation systems it is possible to have an electric to thermal performance ratio of 1.15 (electricity use in relation to heat savings), a pay back period of 7 years and a saving of primary energy per dwelling of about 4,000 kWh per year.

The PV-Vent system consists in addition to PV panels of a low-energy ventilation system with counter flow heat recovery. In the system there is a ventilation air heat exchanger with a high efficiency, an electrical switch box for using PV electricity directly for ventilation fans, and the air for the ventilation system is preheated behind the PV panels and is cooling the panels for improved efficiency.

Lessons learned

- This project showed that energy savings on ventilation is possible and efficient
- An efficiency of 80-85% was reached on the heat recovery
- Good experiences using pro-active builders for a research and development project
- Total cost could be lowered to 3.100 – 3.300 Euros (from 5.330 Euros) with further experiences with the solutions
- Good way of introducing the PV- Vent system that may be utilised by others in future projects
- Different ways of integrating PV-VENT systems in the buildings envelope have been successfully tested and developed

State-of-the-art	
Before renovation	**After renovation**
Constructions [U-values: W/m^{2}K] • Natural ventilation	*Constructions [U-values: W/m^{2}K]* • New windows [1,8] *Installations* • PV-Vent • Heat recovery ventilation • PV system

For more detailed information, please download the best practice example no. 4 from Denmark from the project homepage: http://ei-education.aarch.dk/.

Sundevedsgade (Denmark)

57 % of savings on energy use
Extension of kitchens with integrated solar wall
PV integration, energy efficiency, heat recovery

Objectives and results

The Hedebygadekarréen project encompassed four apartment-blocks. The housing block renovation is the largest urban ecology project in Denmark. A special contribution of 5.3 Million Euro was given by Ministry of Housing.

One of the measures included that a 35 m² solar heating system was installed on the roof for domestic hot water. 60 m² PV-modules were mounted on the two original stair turrets. Preheating of the air in the stair turrets cools the back of the PV-modules and in this way, the transmission loss between the stairs and the apartments is reduced. In the attic, there are two high efficient counter flow heat recovery units from EcoVent, which cover 10 apartments each. A significant amount of energy and money is saved by using a solution with centrally placed versus conventionally placed radiators. In a 70 m² apartment this is equal to a total saving of the investments of 5,700 DKK (765 €), which are primary coming from the use of centrally placed riser pipes.

Lessons learned

The Hedebygade housing block renovation is the largest urban ecology project in Denmark. A special contribution of 5,3 MEuro was given from the ministry of housing. Besides funding from European Green Cities, EU-project (see: www.europeangreencities.com)

- The total water consumption is even lower then the 10 % reduction which was the aim of the project. The monitored months show a reduction of 65 % comparing to the average.
- The solar heating system performs very well.
- The electricity consumption turned out to be higher than predicted. This can be due to the fact that the laundry machines for common use are installed in the monitored network. Excessive use of these machines can lead to this high electricity use. Also the ventilation system and pumps use electricity.

State-of-the-art	
Before renovation	**After renovation**
• Single windows *Installations* • Individual heating (electricity, gas, petroleum)	• Double windows *Installations* • Low temperature heating assisted by PV and Solar heating system. • Heat recovery on ventilation air.

For more detailed information, please download the best practice example no. 3 from Denmark from the project homepage: http://ei-education.aarch.dk/.

L'isle d'Abeau (France)

61 % energy saving.
Reduction of running cost in social housing through energy and water savings.

Objectives and results

Apartments had high running costs, so the retrofit programme was elaborated in order to increase the level of comfort and decrease expenses on water and energy, which is an important beneficial side effect in social housing. In these buildings there was a lot of turnover and a high vacancy rate because of the high level of maintenance costs for heat (electric heating) and for domestic hot water. The retrofit programme stands out as a total environmental approach, which aims to lower the energy consumption by some 40% through enhanced heating systems and education of end users. The total maintenance costs were aimed to be decreased by 35%.

Lessons learned

The buildings were erected in the seventies and eighties, and can thus represent a good example to many other European cities with similar buildings together with social and ecological problems. Although there were some problems when the installation was started up, it is now running efficiently. The acceptance by the tenants is obtained. They feel an improvement of their comfort, especially for heating, and they are very satisfied with the reduction in maintenance costs. The overheating due to the former glass roof is also often mentioned. The inside hall is now a comfortable place for the tenants to meet.

State-of-the-art	
Before renovation	**After renovation**
Installations • Private electric heating system	*Installations* • High energy efficient gas boiler • 165m² Solar thermal panels for domestic hot water and PV operated pumps • 50m² Photovoltaic cells for ventilation and low energy lightning in common areas • Energy Management System

For more detailed information, please download the best practice example no. 7 from France from the project homepage: http://ei-education.aarch.dk/.

Big Heimbau (Germany)

50 % energy saving for heating & DHW
35 m² thermal solar plant

Objectives and results

Two old multi-storey buildings in Engelsby, Germany were renovated, implementing new and innovative solar based techniques. The innovative energy elements are: solar collectors for domestic hot water, advanced glazed balconies, solar walls, advanced glazed staircases, demand controlled moisture regulated ventilation. These elements are integrated in a new heating and ventilation system for the building. The energy demand for heating, ventilation and domestic hot water is reduced by more than 50 %. Furthermore, significant improvements of the thermal comfort and the air quality were accomplished.

Lessons learned

Following the refurbishment of these blocks, the housing company, BIG Heimbau, now has a very low vacancy rate and turnover, whereas before renovation this rate was approximately 30% of apartments.

State-of-the-art	
Before renovation	**After renovation**
Constructions [U-values: W/m²K] • Poorly insulated roof [0.85] • Insulated ground floor [] • Non-insulated wall [1.2] • Single glazed window [5.1]	*Constructions [U-values: W/m²K]* • Insulation of roof, 12 cm of polystyrene [0.20] • Insulation of ground floor: no change [] • Insulation of blind walls [0.27] • Aluminum frame double glazed Low-E window: [2.2] • Insulation of thermal bridges
Installations • Communal boiler for the tow buildings	*Installations* • 35 m² of solar collectors (DHW)

For more detailed information, please download the best practice example no. 2 from Germany from the project homepage: http://ei-education.aarch.dk/.

Lausanne (Switzerland)

62 % energy saving
Moderate rise of total living expenses after renovation

Objectives and results

A frequently upcoming problem after the replacement of old windows with new air tight ones is condensation and mould. The building owner wanted avoid these problems by installation of a balanced ventilation system, which needs an intervention in apartments. This was not desired by the tenants and the owner. The smart solution was an integral planning of the envelope upgrading and hiding the air distribution pipes in the first layer of the façade insulation. The result is a high energy performance building with very light interventions in apartments and relatively low costs.

The building was audited in the framework of the Hope European research project. The planned energy performance is confirmed even 6 years after refurbishment. The indoor environment quality has reached satisfactory levels and the building was classified as one of the "low energy – high indoor environment quality – healthy" Swiss buildings audited.

Lessons learned

- Balanced ventilation with heat recovery can be achieved even if interior interventions must be avoided.
- Indoor environment quality, healthy buildings and high energy performance are compatible objectives.
- Glazed balconies are not used in an optimum way by 100 percent of tenants. Some are heated with electrical heaters to extend living area and some are left with open windows reducing the greenhouse effect of the glazed loggias.

State-of-the-art	
Before renovation	**After renovation**
Constructions [U-values: W/m^{2}K] • Poorly insulated roof • Poor façade insulation (3 cm insulation) • Double glazing [3]	*Constructions [U-values: W/m^{2}K]* • Insulation of roof [0.2] • Insulation of façades [0.23] • High efficiency glazing (HR++) [1.6] • Glazed balconies
Installations • Natural ventilation not controlled • District heating	*Installations* • Balanced ventilation with 83% heat recovery • Low consumption air handling units (0.6 Wh/m^3) • Air distribution inside the façade

For more detailed information, please download the best practice example no. 5 from Switzerland from the project homepage: http://ei-education.aarch.dk/.

5.3 Policy & Strategy

Steyr (Austria)
70 % energy saving
Breakaway of the balconies in an occupied building
Nearly free of thermal bridges

Objectives and results

Before starting the renovation, the housing association compared two different strategies in renovating the façade: The first option was the normal, well-known renovation approach and the second option was to demolish the old balconies, to insulate the outside walls and then to construct completely new balconies. The second option was chosen. The big challenge was to guarantee the security for the tenants, because they were living in the building when the balconies were broken down and the new ones were built. They could not open their windows for some time, as this would have been too dangerous.

If the façade of a building is provided with a thermal insulation, normally the depth of balconies is reduced, which is met with high resistance by the tenants. In this case, the depth of the balconies increased from 1 meter to 2 meters. All renovation measures achieved savings of energy of 70 %. The renovation of the façade with a simultaneous demolition of the balconies was a pilot project which was realised successfully.

Lessons learned

- If the façade of a building is provided with a thermal insulation, normally the depth of balconies is reduced automatically. That is why they then cannot be used well any longer. In this case, this problem could be avoided – in the opposite – the depth of the balconies increased from 1 meter to 2 meters.
- The renovation of the façade with a simultaneous demolition of the balconies was a pilot project which was realised successfully.
- At the moment further projects in Wels and Schwanenstadt are carried out in the same way.

State-of-the-art	
Before renovation	**After renovation**
Constructions [U-values: W/m²K] • Top ceiling [4.41] • Ground floor [1.77] • Outside walls [0.79] • Windows [2.50] *Installations* • District heating • Some flats without balcony	*Constructions [U-values: W/m²K]* • Insulation of top ceiling [0.19] • Insulation of ground floor [0.42] • Insulation of outside walls [0.23] • Windows [1.2] *Installations* • District heating • Renovation of the roof • Mantelpiece • New entrance door • Completely new balconies for all apartments

For more detailed information, please download the best practice example no. 8 from Austria from the project homepage: http://ei-education.aarch.dk/.

Radomir 2 (Bulgaria)

47 % energy saving
Improved building with longer life span
Better comfort, less energy consumption

Objectives and results

The objectives of this pilot project were to show the possibilities to save energy in apartment buildings through the implementation of different energy saving measures and to assess the viability of different technologies used at building refurbishment. In three typical dwelling buildings, erected with prefabricated concrete panels, different energy saving measures were implemented. The implemented measures showed that with simple technologies significant energy savings can be reached – more than 46%. These measures are applicable for 30% of the dwellings in the country.

Lessons learned

- Simple measures as insulation of external walls and roof lead to high energy savings;
- The change of existing double glazed windows should be assessed for each building. If the windows are in good condition, it is better to repair and draught-proof them instead to change them. The pay-back period of new windows only from energy saving is too long.
- It is essential to involve all owners and inhabitants still in the beginning of the refurbishment process.

State-of-the-art	
Before renovation	**After renovation**
Constructions [U-values: W/m²K] • Roof *[0,9]* • Non-insulated basement *[2,9]* • Non-insulated external concrete walls *[2,95]* • Double glazed wooden windows *[2,9]*	*Constructions [U-values: W/m²K]* • Additional insulation of roof *[0,5]* • Insulation of basement ceiling *[0,52]* • Insulation of external concrete walls *[0,52]* • New PVC windows *[1,8]*
Installations • No boiler • No control of the heating system • No control of radiators	*Installations* • Installation of new efficient boiler for central heating • Presetting heat radiation; optimum adjustment of the heating curve with weather-dependent flow temperature regulation • Fixing of thermostatic valves, timer-controls and heat meters on radiators

For more detailed information, please download the best practice example no. 2 from Bulgaria from the project homepage: http://ei-education.aarch.dk/.

Raamsdonk (Netherlands)

Maximal parcel of measures: 70 % gas saving
Rent and energy saving guaranty given by housing association
External insulation bricks for façades - new look!

Objectives and results
With this renovation project, the intention of the Volksbelang housing association was the improvement of the construction quality, the quality of living and energy savings. The Volksbelang managed to persuade tenants to agree to the realization of energy saving measures by means of giving a guarantee for the rent and by renovation of a model house in which all measures were realised and displayed to tenants. The average energy saving of 50 % were achieved by means of proven efficient technologies and is therefore feasible for most housing associations.

The Volksbelang housing association has decided to give a guarantee that the tenants will not have high expenses for the renovation. The guarantee was given that the first five years the rent (total living expenses: bare rent, energy costs and maintenance) will not increase by more than 0.5 % than the average rent in this housing association. Comfort increasing measures were offered to the tenants in the form of "measure packages", which included: a dormer window in the bedroom, fixed trap case to the attic and a more luxurious version of the kitchen unit. For comfort measures, the rent was increased.

Lessons learned
The Volksbelang housing association has made the investment in the renovation in order to minimize the rent increase. The Volksbelang is satisfied with the result and has started a renovation project with 95 houses, based on the principles and experience gathered at the renovation of dwellings in the Cornelis Oomestraat.

State-of-the-art

Before renovation	**After renovation**
Constructions [U-values: W/m^2K]	*Constructions [U-values: W/m^2K]*
• Non-insulated roof (most of dwellings) [1.78]	• External insulation of roof [0.30]
• Non- insulated cavity façades [1.92]	• External insulation of cavity façades [0.35]
• Wooden or steal window frames	• New or adjusted insulation window frames
• Single [5,1] [3] or double glazing [2.9]	• High efficiency glazing (HR++) [1.1-1.3][4]
• Several houses have been insulated after 1980	• Chimneys wrapped in insulation casing
Installations	*Installations*
• Individual boilers (conventional or higher efficiency)	• Individual boilers with improved (4 dwellings) or high efficiency (8 dwellings)
• Local heating devices (13 dwellings)	• Solar collector (12 dwellings)
• Local kitchen gas boiler for DHW (36 dwellings)	• Mechanical ventilation
• Natural ventilation	• Heat recovery based on ventilation air (80% eff.)

For more detailed information, please download the best practice example no. 9 from the Netherlands from the project homepage: http://ei-education.aarch.dk/.

[3] Total U-value of glazing and the window frame
[4] U-value of the glazing only

Ljubljana – Hermana (Slovenia)

63 % energy saving
Total living expenses lower than before renovation
Innovative technologies: passive house standard building envelope

Objectives and results

The main reasons for the renovation were an insufficient maintenance state, bad quality window frames, the intention of the housing association to implement energy saving measures and to improve the aesthetical view of façades. An EC demonstration project enabled the design and execution of the passive standard building envelope in social housing sector, an energy saving of 63 % was achieved. More ambitious measures like monitoring system and management & control systems (BMS, heating management and control, comfort control and information system) were unfortunately not implemented, due to financial reasons and long procedures of public procurement. A mechanical ventilation system with heat recovery is one of the first future measures to be implemented.

Lessons learned

- EC demonstration project enabled the design and execution of the passive standard building envelope in social housing,
- more ambitious measures like monitoring system and management & control systems were unfortunately not implemented, due to financial reasons and long procedures of public procurement;
- A controlled ventilation system with heat recovery is one of the first future measures to be implemented.

State-of-the-art	
Before renovation	**After renovation**
Constructions [U-values: W/m²K] • Non-insulated facade [1,2] • Non-insulated roof [1,0] • Non-insulated ground floor [0,9] • windows (double glazing, wood frame) [2,3] [5]	*Constructions [U-values: W/m²K]* • Insulation of facade [0,16] • Insulation of roof [0,19] • Insulation of ground floor [0,36] • replaced windows (low-e + argon glazing) [1,4] • Solar protection: roler blinds • Night insulation: thermally insulated roller blinds
Installations	*Installations (in progress):* • Management and control system: BMS, heating system management and control • Comfort control and information system: consumption, impacts and comfort

For more detailed information, please download the best practice example no. 2 from Slovenia from the project homepage: http://ei-education.aarch.dk/.

[5] Total U-value of glazing and the window frame

Göteborg (Sweden)

Energy savings: 44 %
Sustainable/bio climatic design
Integration of renewable energy

Objectives and results

In the housing area of Gårdsten, the public housing company Gårdstensbostäder has renovated the residential buildings with a focus on energy efficiency, the integration of renewable energy, sustainable/bioclimatic design and improved quality of life. The renovation was planned and performed in close co-operation with the tenants.

The three 7-storey balcony-access buildings have received new pitched roofs. Prefabricated roof modules of flat plate solar collectors were installed on the south facing part of the new roofs. The modules function both as solar collectors and as roofs. The solar collectors preheat domestic hot water for all apartments on the estate. An innovative air heated solar system was applied to a 3-storey building where solar collectors are mounted on the south-facing wall. External insulation was added to the north, east and west, leaving an open space to the original facade where heated air from the solar collectors is transported. Heat is stored in the thermal mass of the original concrete facade elements. The joints between elements, which before renovation resulted in large heat losses, now allow the warm air into the apartments. When the cooler air reaches the bottom of the wall cavity, it is returned to the solar collector to be re-heated. The system is closed and separate from the ventilation system.

Lessons learned

- The project is considered as one of the most ambitious and successful renovation projects in Gothenburg.

State-of-the-art	
Before renovation	**After renovation**
	Installations • Solar collectors for pre-heating of domestic hot water • Storage tank for solar heated water

For more detailed information, please download the best practice example no. 1 from Sweden from the project homepage: http://ei-education.aarch.dk/.

5.4 Organisation & Financing

Sofia, Zaharna Fabrika (Bulgaria)

46 % energy saving
Improved and enlarged building
Flexible financing schemes allow owners with low incomes to realize the refurbishment of their dwellings

Objectives and results

The objectives of this project were to carry out a renovation and further maintenance of a apartment building in which flats are owned by the tenants, overcoming the problems that arise from the low incomes of the owners and their different interests. The renovation should also lead to a lower energy consumption and improvement of the comfort of the flats.

The project includes also a whole reconstruction of the roof. On the last floor (attic) there were two common premises that were transformed in small flats. The rent of these new flats will help the reimbursement of the loan.

Lessons learned

- For the realization of refurbishment of a multi-dwelling building it is necessary to involve all owners and to organise them in an association;
- The costs of refurbishment can be, at least partially, covered by an extension of the building. Most of the buildings could be extended with an additional floor;
- The financing institutions should be flexible when giving loans for such projects, most of the owners are with low or medium incomes and the banks should take this into account.

State-of-the-art

Before renovation	**After renovation**
Constructions [U-values: W/m^{2}K]	*Constructions [U-values: W/m^{2}K]*
• Roof	• New insulated roof 0,5
• Non-insulated basement	• Insulation of basement ceiling 0.52
• Non-insulated external brick walls	• Insulation of external brick walls 0,52
• Double glazed wooden window s 2,9	• New double glazed windows with PVC frames
Installations	*Installations*
▪ Heat substation supplied by district heating	• Improvement of the heating system (balance, insulation of pipes)

For more detailed information, please download the best practice example no. 4 from Bulgaria from the project homepage: http://ei-education.aarch.dk/.

Kuldiga, Mucenieku nams (Latvia)

70 % energy saving
Total living expenses lower than before renovation
Satisfied tenants

Objectives and results

In summer 2001, the cooperative decided to take a loan for energy efficiency measures and reconstruction of the building. The main reasons for taking the loan were to increase the thermal comfort in the building; to decrease the costs for heat and to improve the appearance of the building. A loan of 63 000 LVL (approx. 100 000 EUR) was taken from the Latvian Mortgage bank for 12 years with the annual interest rate of 10% (in 2002 the interest rate was decreased to 7.5%). The loan is paid back from the payments for maintenance, which was increased to 0.30 LVL/m^2month (0.50 EUR/m^2month).

The statement of the building owner/user about the positive effects of the renovation: some inhabitants were willing to sell apartments before reconstruction of the building but as the value of the property has risen after reconstruction, they have changed their mind. The average room temperature after reconstruction increased from 15°C to 20°C and the inhabitants of the building are satisfied and feel cozy and comfortable.

Lessons learned

- The implementation of usual energy efficiency measures as: insulation of the external envelope of the building and improvement of windows, lead to an increase of the comfort and decrease of costs for heating and maintenance.
- It is essential to have a good financing scheme.

State-of-the-art

Before renovation	**After renovation**
Constructions [U-values: W/m^2K] • Non-insulated roof • Ground floor – reinforced concrete panels 3,808 • Façade walls - aeroconcrete 0,766 • Double-glazed windows with wooden frames • End walls – bricks and reinforced concrete panels 0,869	*Constructions [U-values: W/m^2K]* • Insulation of attic with mineral wool (20 cm) • Insulation of ceiling of basement with polystirol (5 cm) • Insulation of external walls walls with polystirol (8 cm) • Partial change of windows with double-glazed with PVC frames • Reconstruction of staircases and draught lobbies
Installations • Heating supplied by district heating network • Hot water prepared for each flat separately (electrical boilers)	*Installations* • Aluminium wires were changed with copper wires

For more detailed information, please download the best practice example no. 2 from Latvia from the project homepage: http://ei-education.aarch.dk/.

Haarlem (Netherlands)

70 % energy saving
Total living expenses after renovation stayed the same
Solar heating and DHW (total capacity of 2MW), heat storage, LT heating

Objectives and results

The three involved housing associations have succeeded to fulfil the main project objectives: to lower the energy consumption by 70 %; to use renewable energy on large-scale and to guarantee that the total living expenses for tenants would not increase. The project has shown that renewable energy system can serve as an aesthetical roof upgrade and be as well a part of an integral energy concept, which includes several innovative technologies and can lower the energy consumption considerably. During the renovation, tenants could move to so-called 'flex-flats' in the surroundings. The tenants have been involved in the project from the beginning through a tenants committee and individual discussions with housing associations. Each apartment building has a new boiler room in the attic with connected solar collectors. The warm water delivered by solar collectors is after-heated by a gas boiler.

"Eneco energy supply company" is the owner of the installation up to the meters. The rest of the installation is in the ownership of housing associations. Eneco has closed a contract per each apartment building for energy supply and maintenance of the heating installations.

Lessons learned

Each housing association has contracted different builders for the same renovation activities. This has not proven to work good. In the future, housing association will just one agreement.

State-of-the-art	
Before renovation	**After renovation**
Constructions [U-values: W/m²K] • Insulated roof • Non-insulated façades • Non-insulated ground floor • Single [5,1] [7] and double glazing *Installations* • Collective central heating boiler with conventional efficiency • Individual open gas boilers for DHW • Natural ventilation • No individual thermostats	*Constructions [U-values: W/m²K]* • Insulation of side façades [0.27] • Insulation of ground floor [0.27] • High efficiency glazing (HR++) [1,2][6] • High efficiency plastic window frames *Installations* • Collective thermal solar plant for central heating and for domestic hot water • 7,6 m² solar collector per dwelling • Mechanical ventilation • Low temperature space heating • Efficient DC fans • Individual thermostats • Underground heat storage • Gas-driven absorption heat pumps

For more detailed information, please download the best practice example no. 2 from the Netherlands from the project homepage: http://ei-education.aarch.dk/.

[6] U-value of the glazing only
[7] Total U-value of glazing and the window frame

Ljubljana - Einspilerjeva (Slovenia)

63 % energy saving
Total living expenses lower than before renovation
Nearly all users have chosen for energy saving measures

Objectives and results

The main reasons for the renovation were the insufficient maintenance state, complaints of users regarding gutters, sewage and draft through bad quality window frames, the further intention of the housing association to implement energy saving measures and to improve the aesthetical view of façades. The building was designed and built in the period when there was no regulation and no requirements regarding the thermal insulation and energy efficiency in buildings. The building codes related to brick structures resulted in U values of approx. 1,6 W/(m^{2}K) for outer wall and the window technology normally applied in that time (double glazed cast windows) resulted in U values of approx. 2,3 W/(m^{2}K) with high air leakage.

The project would not have succeeded without co-operation and without financial contribution of the occupants and state subsidies. The benefit for the occupants is manifested through lower heating costs and higher level of thermal comfort.

Lessons learned

- The envelope measures enabled significant energy and costs savings. Users' awareness and living habits are expected to have additional positive effect on the savings.
- For the success of this project the co-operation of flat owners and users was essential. An investment in technical improvement of the building condition requires a high level of consensus and a considerable investment. The state subsidy for energy refurbishment was used to support the organisation and execution of works. The benefit for the occupants are lower heating costs, higher level of thermal comfort, improved aesthetic and overall value of the building.

State-of-the-art	
Before renovation	**After renovation**
Constructions [U-values: W/m^{2}K] • Non-insulated facade [1,6] • Non-insulated roof [2] • windows (double glazing, wood frame) [2,3]	*Constructions [U-values: W/m^{2}K]* • Insulation of facade [0,35] • Insulation of roof [0,4] • replaced windows 40%(low-e + argon glazing) [1,4]

For more detailed information, please download the best practice example no. 3 from Slovenia from the project homepage: http://ei-education.aarch.dk/.

5.5 Summary

The energy standards of buildings are different from region to region and from country to country. That is why the examples cannot be ranked by the energy performance indicator. What in some regions is already state-of-the-art is in other parts of Europe maybe not achievable yet. Also the needs and requirements are not the same for all people – and the incomes vary as well. However, some goals are the same in all regions: saving as much energy as possible, saving money and helping to use our resources efficiently.

5.5.1. Main refurbishment measures

The main measures taken can be divided in the following types:

- *High envelope performance*
    - Insulation of façades
    - Insulation of the roof
    - Insulation of the top ceiling
    - Insulation of the ground floor
    - Double glazed windows with PVC frames
    - Renovation of the balconies
    - Renovation of the entrances
- *Improvement of the heating systems*
    - Insulation of distribution pipes
    - Management and control system
    - Installation of heat meters
    - Installation of heat valves
    - New energy-efficient boilers
- *Installations*
    - Mechanical ventilation with heat recovery
- *Renewable energy sources*
    - Solar thermal collectors
    - PV-systems

The above mentioned measures are the main conventional solutions and with them high energy performance can also be achieved.

5.5.2 Lessons learned and conclusions from the best practice examples

Each of the more than 60 collected best practice examples includes a paragraph dealing with lessons learned and a paragraph dealing with conclusions on the specified renovation project. It is not surprising that these lessons learned and conclusions are often very similar, although, of course, most projects have their own special conclusions. The following points display some common lessons learned:

- It is worthwhile to involve and inform the occupants well and to listen to their wishes and proposals and, where possible, to fulfil some of them.
- It is very important to involve all occupants in the process of refurbishment.
- The energy saving potential is very high but is dependant also on the user behaviour.
- The individual heat recovery ventilation system has performed well and contributed to a much improved indoor air climate.
- The improvements of the apartment buildings increase their quality and the living comfort.
- The installation of solar thermal plants for the production of domestic hot water is a good solution.
- The total living costs after the renovation are in most cases much lower than before renovation.

References and additional reading

6. Recommendations to overcome barriers and support drivers

This chapter is listing typical barriers and drivers for energy intelligent retrofitting in Europe – and recommendations on how to manage and continue the important work with energy savings.

Barriers
Major barriers to accelerated housing refurbishments are generally related to financing, ownership structures and awareness:

- Lack of suitable financial mechanisms - Given the enormous amount of houses that need to be refurbished, the available public financial sources and programmes are limited.
- Conditions for access to capital (e.g. mortgages) remain relatively restricted and a large part of the population does not qualify for loans. Furthermore, an important psychological barrier is that people are not yet used to take loans.
- Transfer of ownership and resulting problems with decision-making about refurbishment - The privatisation of the housing stock in the new Member States leads to complex decision-making processes among the new home-owners.
- Lack of awareness among residents towards new energy efficient technologies and the experience with starting a refurbishment project.
- Little to no awareness adapted information available from independent agencies.

Drivers
The main drivers for housing refurbishment are related to:

- The building is modernized.
- The living comforts are increased.
- Energy savings can be obtained.
- The CO_2 emmissions are lowered.
- Rapidly increasing prices of the main energy carriers will make housing refurbishment projects more economically feasible.
- The aging and deteriorating housing stock increases the need for refurbishment. It extends the lifetime of the existing housing stock and represents a far cheaper option than building new houses.
- Housing refurbishment and increasing the energy performance will make the housing stock more attractive; possibility to increase rent of rental housing and increase of real estate value of owner-occupied dwellings.
- It might be easier to rent or sell the apartments.

Recommendations
Recommendations to accelerating social housing refurbishments are related to information and inspiration on the actual solutions and effects of the solutions, involving the tenants, strengthening institutional structures, coordinating grant programmes and facilitate access to private financing.

Due to the high share of private ownership in the new Member States it is necessary to motivate homeowners to form homeowner associations. These homeowner associations should receive a legal status, so that they may represent homeowners when undertaking refurbishments.

Grant programmes in both old and new Member States are dependent on limited government budgets. Therefore, they should be focused on limited types of projects instead of providing generic support.

Examples are:

- Use of grant schemes for complete refurbishments or for combinations of technologies or for new less conventional technologies that are less accessible due to their high purchase price.
- Use grant support for project preparation. Preparation of refurbishment projects usually means a lot of work and not all residents are able to prepare a well-prepared refurbishment project for their

dwelling. Providing grants for energy audits or project preparation activities could greatly overcome the knowledge barrier among residents.

- Design grant or soft loan programmes specifically aimed at weaker social groups. These groups have often little financial possibility to finance refurbishment and are also heavily affected by increasing energy prices.

The EI-Education project hope that the EI-Education guidebook and platform can lead to increased awareness among administrators, technicians and residents in non-refurbished dwellings so that they become aware of the technical and financial possibilities of housing refurbishment. As there have been both good as less good examples of housing refurbishment projects it is of major importance to disseminate good project examples. Therefore, focus in the EI-Education has ben on best practice examples. Use the examples for saving energy use by the refurbishment.

References and additional reading

7. Further information

Project homepage
http://ei-education.aarch.dk/

Find on the homepage:
- An introduction to the EI-Education project
- a electronic version of the Guidebook
- an overview of good practice examples

Literature
"Financing social housing refurbishment - Overview report for the InoFin project", supported by the European Commission

"Regular National Report on Housing Developments in European Countries" by the Department of the Environment, Heritage and Local Government, Dublin, Ireland (can be downloaded at the CECODHAS website at – www.cecodhas.org.)

Related EU projects

Green Catalogue: the aim of the "GREEN Catalogue" project (where G.R.E.E.N. is also an acronym of Global Renewable Energy Efficient Neighbourhoods) is to develop a catalogue or manual with a definition of performance indicators and performance requirements/recommendations for best practice technologies in the area of Rational Use of Energy (RUE) and Renewable Energy Systems (RES) in buildings. A working group of experienced partners concerning practical use of RUE and RES in buildings has here received a feedback concerning 32 different building related technologies from 180-200 producers, builders, cities, energy offices and energy companies in 10 different EU-countries. Read more on the project homepage: www.greencatalogue

InoFin project

Report: "Experiences with financing social housing refurbishment WP2 overview report for the InoFin project", M. ten Donkelaar. ECN-E--07-012 February 2007. Link to report:
http://www.ecn.nl/publicaties/default.aspx?nr=ECN-E--07-012

Report: "Financing energy saving measures in the Dutch social housing sector. WP2 report to the InoFin project" M. ten Donkelaar, Y.H.A. Boerakker, B. Jablonska, C. Tigchelaar. ECN-E--06-049 December 2006. Link to report:
http://www.ecn.nl/publicaties/default.aspx?nr=ECN-E--06-049

http://ei-education.aarch.dk