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April 3, 2008

## Passive house retrofit: Taking it easy

by Martin Ploss

Improving the overall efficiency of a nation's housing stock by insisting new buildings reach the impressive passive house standard can mean a 90% energy saving and a high level of thermal comfort. Martin Ploss explains how it also makes for an increasing role for renewables in the built environment.

In many central European countries energy consumption for heating and domestic hot water causes around one third of national CO2 emissions. For this reason the reduction of energy demand from buildings plays an important role in efforts to control anthropogenic greenhouse gas emissions.

As measurements in several hundred different types of accommodation show, energy consumption in new houses can be reduced drastically. For instance, while a typical new single family house in Austria has a specific space heat demand of 75 kWh/m<sup>2</sup> of treated floor area (TFA), the demand of a so called 'passive house' is 15 kWh/m<sup>2</sup>TFA or less.

Furthermore, in recent years the market share of new passive houses in Austria has grown significantly. More than 2000 passive houses have been erected in the last decade. In Vienna, large settlements are to be developed to passive house standard, and in the region of Vorarlberg in western Austria, social housing companies have been obliged to build to passive house standard since 2007. More recently, a broader spread of building types has been realized in passive house-standard, including office buildings, schools, kindergartens, super-markets and others. Both the German and Swiss markets are seeing similar developments too, and while passive house was a standard mainly limited to the German-speaking countries initially, the past five years have seen it begin to spread across Europe. This was partly due to European research and development (R&D) projects such as the Promotion of European Passive houses (PEP) programme or the Passive On programme.

Today, 'passive house' is a clearly defined standard across most of Europe for buildings of a very high energetic performance. Experience has shown that a single definition of the passive house can be used at least from 40°-60° latitude, and passive house definition has been tested in both Scandinavia and southern Europe. Key parameters are a specific space heat demand maximum of 15 kWh/m<sup>2</sup> TFA, a specific primary energy demand for space heating, cooling, domestic hot water, electricity for pumps and ventilation and household appliances at a maximum of 120 kWh/m<sup>2</sup> TFA, a maximum heat load of 10 W/m<sup>2</sup> TFA, and an airtightness of n50 0.6/h maximum.

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### **Retrofitting passive house components**

Although the successful implementation of passive houses in new buildings plays an important role in the overall strategy to reduce greenhouse gas emissions, the improvement of the energetic quality of the existing building stock is of even bigger importance. In Austria, the yearly rate of new built apartments is about 1% of the existing building stock. Depending on age and building type, the specific space heat demand is 130–280 kWh/m<sup>2</sup>. As only about 1%–1.5% of the building stock is retrofitted per year and this rate cannot be increased to much more than 2.5%, the improvement of the energetic quality of retrofits is essential in order to reach the national, European and international targets for the reduction of greenhouse gases.

However, since 2001, more and more renovations in Austria, Germany and Switzerland have been carried out using components that had previously been tested in new passive houses. Different names are used for these houses, sometimes called 'factor 10-houses' as the energy demand after renovation is only a tenth of the original demand.

In these projects, a specific heat demand after renovation of 15 kWh/m<sup>2</sup> TFA, was achieved.

The main elements of the energy concept are typical passive house components:

- Excellent insulation level of opaque building elements: u-values range from 0.10 W/m<sup>2</sup>K for walls and roof to 0.18 W/m<sup>2</sup>K for basement ceilings.
- Triple glazed windows with adequate frames and an optimized installation.
- Thermal bridges reduced to a minimum.
- The airtightness was improved by a factor of 6–10, the limiting value for new passive houses was achieved.
- A ventilation system with highly efficient heat recovery installed.
- Thermal solar collectors installed covering up 60% of the annual energy demand for domestic hot water.
- Highly efficient condensing gas boilers were installed; where possible, ducts have been insulated to a very good level; in other projects biomass boilers have been successfully tested.

### **Benefits of the retrofit programme**

Experience with the renovations up to passive house standard is so far very good in the Vorarlberg projects, as well as in projects in other regions of Austria, Germany and Switzerland.

Thermal comfort has been improved to a level superior to that of a conventional new house; due to the ventilation system the air quality is improved, and energy bills are reduced drastically. As thermal bridges are minimized, the airtightness is significantly improved and the air exchange is always up to hygienic standards due to the ventilation system; the main causes for structural damage and mould problems are also eliminated.

Furthermore, the measured energy consumption shows good congruence to the demand that was calculated in advance using the passive house planning package (PHPP).

Austrian and German research has shown that for bigger apartment buildings renovations to passive house standard or very close to it cost about a450–600/m<sup>2</sup> TFA. The extra cost compared to a renovation up to national building code is in the range a80–150/m<sup>2</sup> TFA.

For comparison a new apartment building costs about a1600/m<sup>2</sup> TFA in western Austria.

Nonetheless, detailed analyses show that most of the measures used in passive house retrofit are economically feasible, for example, the overall lifecycle cost for investment and energy is lower using the passive house insulation of 26 cm compared to the building code insulation of 12 cm. As for most renovations lifecycle costs are not calculated, home owners and housing companies tend to realize suboptimal insulation thicknesses, for example.

In some regions of Austria, the regional funding system therefore differentiates the rate of funding according to the energetic quality of the house after renovation – the lower the energy demand, the higher the funding. The experience in Austria, with nine different funding systems in its nine regions, shows that this funding rate differentiation is an effective way of encouraging very high quality standards.

### **Rolling out retrofitting tools**

After demonstrating the technical and economic feasibility of renovations with passive house components in several R&D projects, the next step is to establish high quality renovations as a standard in all European countries.

The e-retrofit tool project, co-financed by the EC's Intelligent Energy Europe programme, aims to inform social housing companies across Europe of the principles, advantages and technical approaches of high quality renovations. Six institutions from five countries are involved in the project, including the Faellesbo social housing company and COWI A/S, both of Denmark, the Energieinstitut Vorarlberg research institute of Austria, the ECN Energy Research Centre of the Netherlands, Asociación de Investigación Industrial de Andalucía, of Spain, and Lithuania's Housing Agency.

The main element of the project is an internet-based tool giving basic information to social housing companies that enables them to find out whether they have apartment buildings in their building stock that are suitable for high quality renovation. Social housing groups have, in particular, been selected as a target group as they are frequently responsible for a very high number of large, identical buildings.

Initially, a common definition of 'passive house renovation' or 'high quality renovation' is required. After a detailed analysis, the following definition was found: 'A passive house retrofit (PHR) is a renovation that improves the specific demand for heating, and cooling in southern countries to a maximum of 30 kWh/m<sup>2</sup> TFA.'

The calculation of the demand is made using the passive house planning package (PHPP). In a second step, a maximum value for the overall primary energy demand shall be added to this definition, the value of 30 kWh/m<sup>2</sup> TFA was fixed. This value was chosen as in some cases it was shown to be prohibitively expensive to reach 15 kWh/m<sup>2</sup> TFA. Even so, many of the projects realised so far have aimed at a specific heating demand of about 25 kWh/m<sup>2</sup> TFA.

For the internet tool, a structure that combines common information for all European countries with country-specific information was developed. Common parts of the tool are an explanation of the different energy standards for passive house and passive house retrofit, a description of the principles of passive house retrofit, its advantages, and about 35 measures feasible under a passive house retrofit programme.

While these measures may differ from country to country due to climatic differences or differences in construction traditions, the main elements are identical.

In a second part of the tool, the implementation of passive house retrofit is demonstrated in building typologies for each of the countries involved in the projects.

For each country, between three and nine building types typical to the building

stock of social housing companies were identified, and for each type calculations made to find out the most promising approach to reaching the energetic aim of a maximum of 30 kWh/m<sup>2</sup> TFA. In most cases, buildings of different ages were analysed and calculations made using PHPP together with regional weather data. For each building type, a proposal for a passive house retrofit (PHR) is given, the measures selected from the list of 35 measures are specified, the specific energy demand for space heating and cooling calculated for three standards: actual state, after renovation according to national building standard, and after PHR. From these figures, the final energy demand for heating, cooling, ventilation and pumps is calculated, as well as the energy costs.

In another table, the energy demands for incomplete passive house retrofits are specified, showing the impact of individual measures on energy demand.

Topics, including costs and economic feasibility, are described in separate chapters. Best practices from 10 European countries are also integrated into the tool, which, in addition to the five participating countries, has been transposed into nine more national versions of the tool. For these countries, such as Italy, France, Portugal, Slovenia, and the Czech Republic among others, the building typologies of the participating countries were used.

Following testing and optimization with social housing companies, architects and engineers, as a final step of the project development, 60 social housing companies in more than 10 European countries were approached and guidance was given at three levels from initial guidance to sketch proposals for some of the projects.

The social housing companies showed great interest in both the tool and in the concept of passive house retrofit. In many cases, the integration of a ventilation system into an existing building was the measure that needed most explanation.

For those countries with no experience in passive house retrofit it would be initially helpful to develop research projects with a detailed planning, an analysis of costs, extra costs and economic feasibility. These projects may be used to define the most efficient funding systems and, as the experiences in the implementation of new passive houses show, the further education of architects, engineers and craftsmen is an important accompanying measure for success.

For examples of passive buildings view the image gallery linked above.

Martin Ploss, Architect Dipl.-Ing, has been planning passive houses since 1995 in his own architectural office at Nonnenhorn in Germany. He has also been a researcher at Energieinstitut Vorarlberg, department of passive house and solar architecture, since 2005.

[The e-retrofit web tool may be found here.](#)

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Author: <a href="#">Mary Saunders</a>	Hello Martin,
Date Posted: <a href="#">April 4, 2008</a>	Thanks so much for posting this. I am part of a group called Re-Code Portland, and the thrust of our advocacy is affordable retro-fit to benefit the willing but unmonied. I will forward this to one of our main geeks.

Comment 1 of 4



Author:  
[Jeff Anderson](#)  
Date Posted:  
April 5, 2008

This is one of the biggest items in a new house construction that is typically over looked. How can heating and cooling cost be reduced. Things like using Structurally Insulated Panels (SIPs) are used in wall and roof construction. Air to air heat exchangers to help recover heatloss when the air is exhausted out of the house. Ground source heat pump for conventional heating, and cooling. Limiting window space on the east and west sides of the house, also on the side of the house that does not receive sunlight in the winter. Then to maximize the windows area on the side of the house that receives the sun light in the winter. Over hangs should block sun light from entering the windows during the summer. Skylights should be eliminated or reduced in size. Since they are solar heat source during the summer. Windows should be double or tripple pane double low E glass that is gas filled. These windows hill have a good insulating value and a low solar heat gain.

[Comment 2 of 4](#)

Author:  
[Jeff Anderson](#)  
Date Posted:  
April 5, 2008

The windows on the side of the house that the sun comes in during winter should have a high solar heat gain but also have good insulating properties. Typically they hare double or tripple pane glass. They may also have single soft low E coating. This is applied to the inside glass pane. This because when radiant heat passes through the glass it reflects off the low E coating, back into the house. If the radiant heat hit the low E coating first it will pass through it and the glass into the house.

[Comment 3 of 4](#)

Author:  
[Mark roeder](#)  
Date Posted:  
April 5, 2008

Thanks for the primer Jeff.  
Some other things that deserve mention.:  
Radiant heating as opposed to energy wasting hot air systems.  
Solar hot water heat.  
Using a building's own mass as a heat battery, releasing heat when needed or cooling overnight when needed.  
What about aerogels or thin film technologies which could make a house energy independent?

[Comment 4 of 4](#)

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