EFFECTS OF ENERGY SAVING MEASURES AT RENOVATION

Margaretha BORGSTRÖM Ph.D[1]

[1] School of Business and Engineering, Halmstad University P O Box 823, 301 18 Halmstad Sweden, Margaretha.Borgstrom@hh.se

Keywords: energy saving measures, dwellings, multi-dwellings buildings, renovation

Summary

This study focuses on the necessity of having knowledge about different energy saving measures when renovations and reconstructions are planned and designed. It is also of great importance to have routines to follow up what effects the actions taken have had on the energy consumption as well as on the indoor climate when the renovation is completed. A big part of the existing buildings in Sweden are built during a ten-year period between 1965 and 1974. When these buildings are to be renovated there is a great potential for energy saving.

1. Introduction

The Swedish government attaches great importance on energy saving. The goal for the government is to reduce the total energy consumption per sq. meter heated floor space in dwellings and non-residential premises with 20% until 2020 and with 50% until 2050, compared with the energy consumption 1995. The use of energy for heating and ventilation can be minimized if the houses are well-insulated and have a controlled air-exchange.

Many dwellings in Sweden were built during a ten-year period between 1965 and 1974. During this period, there were no requirements on low energy consumption in buildings, so there when these buildings are to be renovated there is a great potential for energy saving. Common energy saving actions are:

- replacing the windows with windows having a low U-value or adding one more pane of glass
- supplementary insulation in the attic
- supplementary insulation of the outer walls
- sealing of windows and doors
- adjusting the heating- and ventilation system
- use of heat recovery system

According to SABO (The Swedish association of municipal housing companies) the interval between façade renovations, change of roof-material or change of windows is 30-40 year. For adjusting heating system the interval is 10 year. Energy saving measures in connection with renovation of facades and roofs are supplementary insulation and changes to more energy efficient windows. Buildings that will be affected by such measures are built from about 1961 to 1980. During this period a large number of dwellings were built in Sweden, about 996 000, which corresponds to about 41% of all dwellings in multi-dwelling buildings in Sweden 2006.

About 30% of all dwellings in multi-dwelling buildings existing the year 2006 have been reconstructed between 1976 and 2006 SCB (2006). Of the dwellings built 1961-80 about 15% have been reconstructed between 1990 and 2006. According to Boverekt (2003), about 50% of the dwellings renovated between 1975 and 2002 have been subject to façade renovations, and on about 56% of the dwellings actions have been taken on the roofs. These measures can be change or repair of the facing, possibly combined with supplementary insulation.

Energy saving measures on the ventilation system consist of adjustments of the existing system and installation of heat recovery system. About 60% of all multi-dwelling buildings in Sweden built before 1975 had natural ventilation in the year 1980, which corresponds to more than 1 million apartments. About 700 000 apartments built before 1975 had in 1980 original mechanical exhaust ventilation. During the 1950´s balanced ventilation was introduced and at 1980 this kind system was used in about 100 000 apartments. When the buildings were modernized in the period 1975 to 2002 about 400 000 apartments have changed ventilation system, totally or partly. 54% of the renovated apartments in multi-dwelling buildings have a changed ventilation system in 2006 Boverket (2003).

When reconstruction/renovating buildings it is important that the actions taken result in buildings with both low energy consumption and a good indoor climate. To obtain knowledge about the effects it is necessary to follow up the energy consumption and to evaluate the indoor climate. Experiences in form of successful solutions and how to avoid bad solutions must be transferred to future building projects. It is necessary that the developer demands low energy consumption and a good indoor climate early in the planning and design phase both when houses are constructed and renovated.

The selection of methods used in renovations are in many cases based on recommendations obtained from computer programs. After renovation very little feedback is received on how effective the energy measures were, whether the energy goal has been reached or if the computer program has given reliable results.

2. Energy efficiency buildings with a good indoor climate

2.1 Energy efficiency in planning and design phase

One example of means for assistance in the planning and design phase for energy efficiency buildings is the so callad “Energilotsen” produced by the companies Skanska Teknik, Cementa, Strusoft and Lunds institute of technology, www.energilotsen.nu. The city of Stockholm have produced a written report called “A program for environmentally adapted construction (miljöanpassat byggande vid nybyggnad)” to help the client to specify his demands in order to obtain energy efficient and sound buildings when constructing multi-dwelling buildings Stockholm Stad (2006).

The project “Teknik för hållbarhet I 50-60-70 talens bostadsområden” has compiled good experiences and facts about measures that enhances the environmental aspects at renovation. The research group has not evaluated the measures Vidén (2004-).

2.2 Evaluation of indoor environment

Today there are many different methods for evaluating the indoor environment. One example of a method to estimate both the indoor and outdoor environment for buildings is the so called “Ecoeffectmetoden”. This method shows the effects concerning energy consumption, use of material, indoor environment, outdoor environment and lifecycle costs. The indoor environment is evaluated by questionnaires, technical measurements and by looking at critical details. Glaumann (1999). One other method is the so called “P-märkning” where the indoor environment is evaluated by inspection and measurements. Defects are measured SP (1995). Evaluating the buildings environmental status and assessing the environment of the building are other methods to study the indoor environment. MIBB (2001). Investigation of indoor environment problems can be carried out by using check-lists Swesiaq (2006) or by using questionnaires Andersson et al.(1990) and Stockholm Stad (1990). Requirements and specifications for the indoor environment are presented in different reports Boverket (1998) and VVS-tekniska föreningen (2006). There is also a method for planning for a good indoor environment Hult (2002).

3 Evaluation of energy saving measures in reconstructed buildings

Two examples on studies involving evaluations of energy saving measures at reconstruction of multi-dwellings buildings in Sweden are the so called “Energisparkvarteren” Anderlind et.al.(1986) and the so called “Högskoleprojektet Elmroth et al. (1989). By realizing energy saving measures in existing buildings all around Sweden and then evaluating them carefully, owner of buildings may be convinced that the energy saving actions are profitable. At the project “Energisparkvarteren” about 1800 apartments built during the 1950´s were evaluated. The measures taken were:

- replacing the windows with windows having low U-value or adding one more pane of glass
- supplementary insulation in the attic
- supplementary insulation of the outer walls
- sealing of windows and doors
- adjusting the heating- and ventilation system
- use of heat recovery system

In these projects no evaluations of the indoor climate have been carried out. The table 1 below shows some examples on the energy savings from different energy saving actions

Table 1 Energy savings from different energy saving actions

Measure	Number of buildings	Energy saving
Adjusting the heating- and ventilation system	5	8%
Adjusting the heating- and ventilation system+ supplementary insulation in the attic (120 mm)+replacing the windows	5	15%
Adjusting the heating- and ventilation system+ supplementary insulation in the attic (120mm)+ supplementary insulation of the outer walls (120mm)	5	18%
Adjusting the heating- and ventilation system+ supplementary insulation in the attic (200mm)+ sealing of windows	9	18%

In the other project "Högskoleprojektet" a number of multi-dwelling buildings been have investigated in order to show the results of different energy saving measures. 36% of the buildings were built before 1940, 37% were built between 1941 and 1969 and 27% were built between 1961 and 1975. Results from the actions taken are shown in table 2.

Table 2 Energy savings from different energy saving actions

Measure	Number of buildings	Energy saving
Replacing the windows	27	9%
Supplementary insulation in the attic	29	5%
Adjusting the heating- and ventilation system+ replacing the windows	6	11%
Adjusting the heating- and ventilation system+ supplementary insulation in the attic or façade	16	11%
Adjusting the heating- and ventilation system+ sealing of windows	10	8%

An important result from the investigation was the knowledge about how different energy saving measures co-operate and how they have influence of each other. The conclusion from "Energisparkvarteren" was that every building must be treated individually when selecting energy saving measures. Measures that give god results in one building can give bad results in another building. Combination of different energy saving measures showed the best results when the combination was made especially for the building in question.

4. Energy saving measures at reconstruction and evaluation after reconstruction

A research project at the University of Halmstad describes the actions taken when renovating buildings constructed between 1966 and 1970 in Halmstad Sweden, Borgström (2006). The purpose of the renovation was to lower the energy consumption and to renew the exterior of the buildings. The actions taken have been evaluated both before and after the reconstruction in order to find out if the right actions have been taken with regard to the energy consumption and the indoor climate. This was done by comparing the measured energy consumption before and after the reconstruction, by measuring the indoor temperature before and after reconstruction and by analyzing some parts of the building where no actions were taken.

Students from Halmstad University have in their degree project compared different actions taken to decrease energy consumption in some of these buildings, Jörgensen, Olsson (2002). This study was made before the renovation. The computer software, Enorm 1000, has been used for the calculations. Calculated measures are replacement of existing windows with triple-glazed windows, supplementary insulation in the attic, supplementary insulation on the facades and all measures used together. Results from the calculation are shown in table 3.

Table 3 Calculated energy savings

Measure	Energy saving
Replacing the windows	8%
Supplementary insulation in the attic (500mm)	2%
Supplementary insulation of the façade (50mm)	28%
All measurements	38%

When the buildings were renovated the actions taken were:

- 100mm supplementary insulation on the attic
- 50mm supplementary insulation of the facades
- The windows in the facades have been replaced by triple-glazed windows
- Adjusting the heating system

- Sealing of balcony door
- New inlet terminal

No actions were taken to neither the external wall nor the windows at the insert balcony. When analyzing the indoor climate it is of interest to look at both those parts where actions have been taken and those parts where nothing was changed. The part of the building that is of special interest is the section composed of the walls and windows at the inset balcony. Measurements have been made of the indoor temperature close this part of the building.

Through this renovation the use of energy have decreased with 19% which is lower than the estimated value. This is due to that the thickness of the insulation used in the attic was 100mm compared to the estimated 500mm. In addition, not all windows were replaced with triple-glazed windows.

The indoor temperature does not exceed the limits for temperatures indoor set by the National Swedish Board of Health and Welfare (2005). When the outdoor temperature is below zero, the surface temperature on the windows at the inset balcony is low. This can result in cold downdraughts and cold radiation and an uncomfortable indoor climate.

5 Conclusions

Following conclusions can be drawn:

- Many dwellings in Sweden were built during a ten-year period between 1965 and 1974. When these buildings are to be renovated there is a great potential for energy saving.
- It is important that all parties in the construction process are joined in aim for low energy consumption and a comfortable indoor climate. It is also important that they are all aware of the close relationship between the use of energy in buildings and the indoor climate.
- It is also important to evaluate the outcome of actions taken at renovation. A good indoor climate should be an important target in the planning and design phase even at renovation.
- It is necessary to increase the knowledge about different energy saving measures that can be used at renovation/reconstruction, and also to establish routines to follow up both the effects on energy consumption and to evaluate the indoor climate after renovation/reconstruction.

6 Further research

Give an overview of the methods some real estate company's uses and describe disadvantages and advantages of the methods.

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