50% Energy Savings by KNX – details and discussion of a promising result

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Abstract

Studies concerning the energy savings potential of building control systems have come to quite different results. The comparison study at Bremen University of Applied Sciences showed heating energy savings up to 50% [1-4], while at the same time a field study of the Bremen Energy Institute in residential buildings with a wireless heating control system revealed no significant change in energy consumption in a two year test period [5].

To assess the energy savings potential of a building several aspects such as thermal protection standard, type of usage and resident behaviour have to be taken into account. A major difference between the two cases presented here is in the type of usage and the user's attitude. The residents of the apartments paid attention to possible waste of energy, e.g. through open windows, to save energy costs. In seminar rooms, by contrast, there is no personal responsibility for the room and it's energy consumption. Building automation can be expected to improve energy efficiency very significantly in those cases.

Introduction

Energy savings in buildings will be a major contribution to the EU climate protection goals. In Germany one third of overall energy consumption comes from this sector. Improved building standards w.r.t. thermal protection and the heating system have been prescribed by legislation to the effect that the average energy consumption of modern buildings is less than a third of older ones. Further improvement will need more sophisticated technical solutions such as

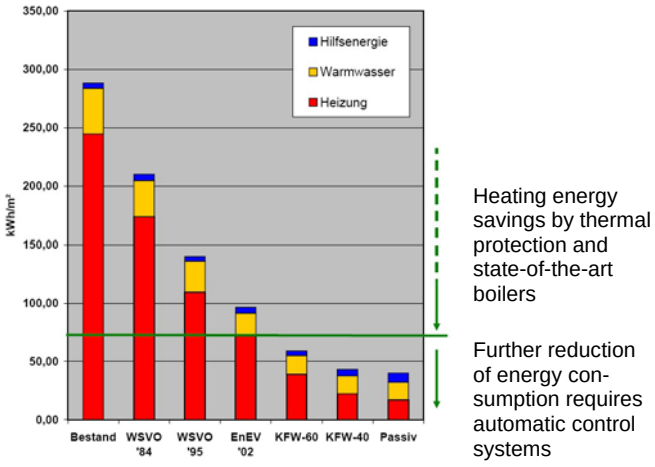

Figure 1: Building standards and future trends

- use of regenerative energy sources,
- controlled ventilation,
- automatic control via installation bus systems.

Individual room control can – and should – be designed to assist the user in providing light, heat, cooling and fresh air exactly as demanded and needed.

This way, waste of energy is minimized in all areas of residential consumption. The overall energy savings potential, however, strongly depends on the actual building standard, on the type of usage as well as the awareness of the users and their capability to operate the installed systems appropriately.

The energy savings effect of automatic control systems in buildings is therefore expected to be quite different in different types of buildings. Two examples are presented here. One is from a university building utilizing an installation bus system for heating and lighting control. The other is a wireless centralized room temperature control system in residential apartments in apartment buildings.

Bremen University of Applied Sciences - KNX-based Control

At Bremen University of Applied Sciences the informatics building (built 2002) was equipped with a KNX-network and a metering system in a part of the 1st floor to conduct an energy consumption comparison study. Two similar adjacent classrooms, one with and the other without KNX-based individual room control, are compared w.r.t. heating and lighting energy demand. The KNX system covers two rooms, one of the seminar rooms and a neighbouring lab. The heating control system in these rooms consists of a room temperature controller and magnetic window contacts shutting the radiator valves. The other room has radiators with standard thermostats. Heating energy consumption is measured for each room. However, the two KNX-controlled rooms are both connected to the same heat meter (see figure 2).

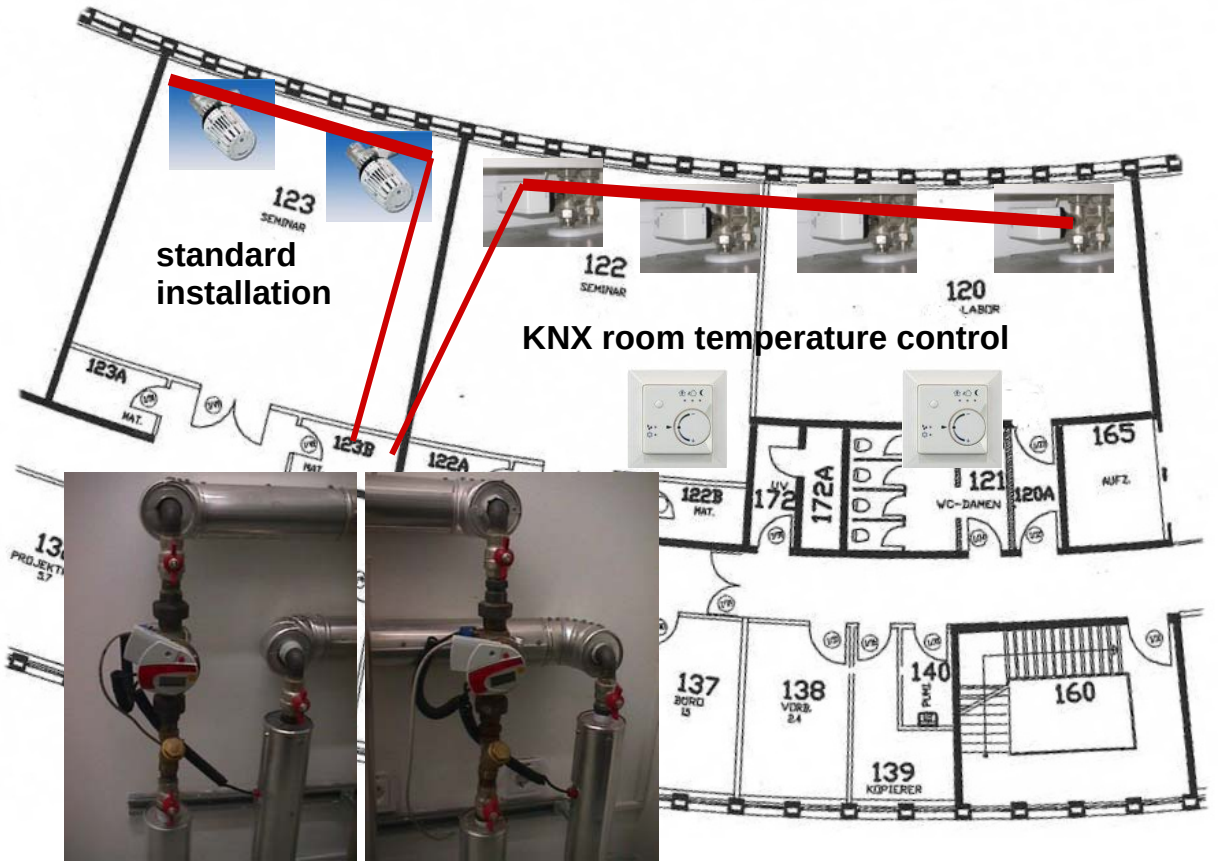

Figure 2: Installation of the heating system for a comparison study of two seminar rooms at Bremen University of Applied Sciences

After approximately three years of operation the heating energy consumption measured for both KNX-controlled rooms together was only half the consumption of the room with standard installation! This can be seen from figure 3 by summer of 2005. To confirm this result, a measurement project was set up to validate the observed savings with respect to

- Comparison of room temperatures,
- Analyze possible heat transfer from neighbouring rooms or rooms below,
- Identification of the main sources of heating energy savings.

In the frame of this project[1] detailed measurements and experimental studies were carried out during the winter months 2006 and 2007. The heating energy consumption until summer 2007 is shown in figure 3.

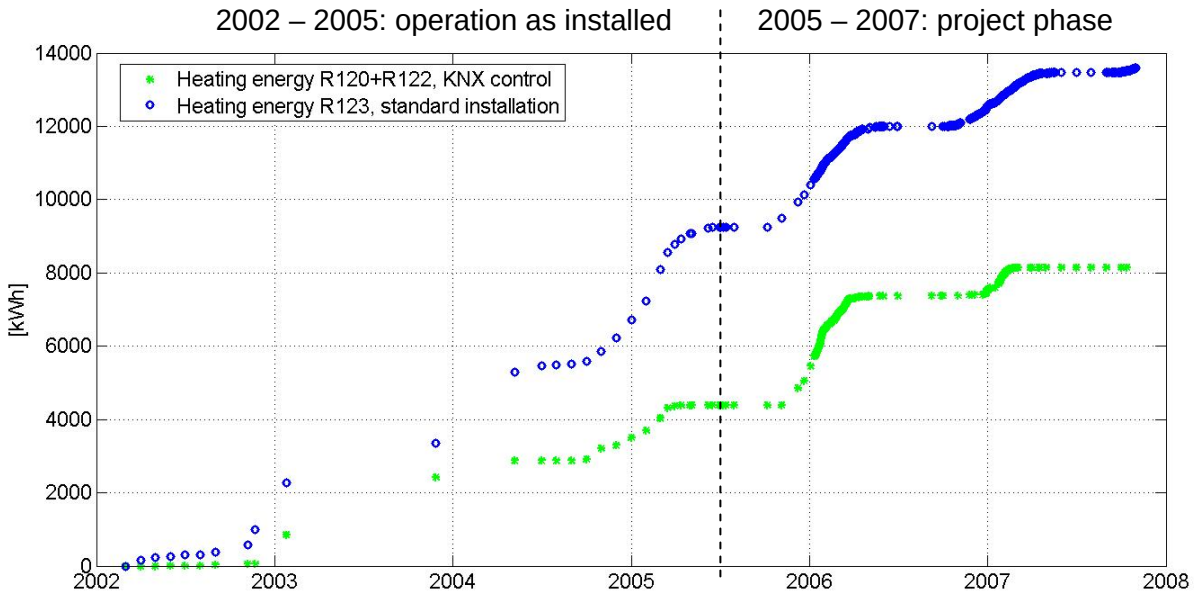

Figure 3: Heating energy consumption in a seminar room and laboratory with KNX-control is significantly lower than in a seminar room with standard thermostats.

The project used a PC-based system for continuous long term measurement data acquisition via the KNX network based on the ELVIS software. The measurements of the heat meters were made available within the KNX network by an M-bus-KNX gateway. Temperature sensors were installed at 3 points in each room and connected to two 4-Channel-Pt1000 interfaces. In addition, presence detectors were installed and the state of the window contacts and the blinds was captured [1].

This way, a detailed comparison of presence, room temperatures and heating energy consumption could be done. It turned out that there was no significant difference in room usage or in user comfort (mean temperature) in the two seminar rooms. Experiments with different temperature control parameter settings showed strong influence on the heating energy consumption. This can be seen from figure 4, where in January 2006 the setpoint of the KNX room temperature controller was changed to values beyond typical comfort levels. During this month heating energy consumption (and the mean temperature) is significantly higher in the controlled room.

[1] The project was funded by Bremer Energie-Konsens GmbH.

In the following two months the parameters were reset to typical values resulting in equal or even lower consumption in the controlled room while maintaining an equal or slightly higher mean room temperature.

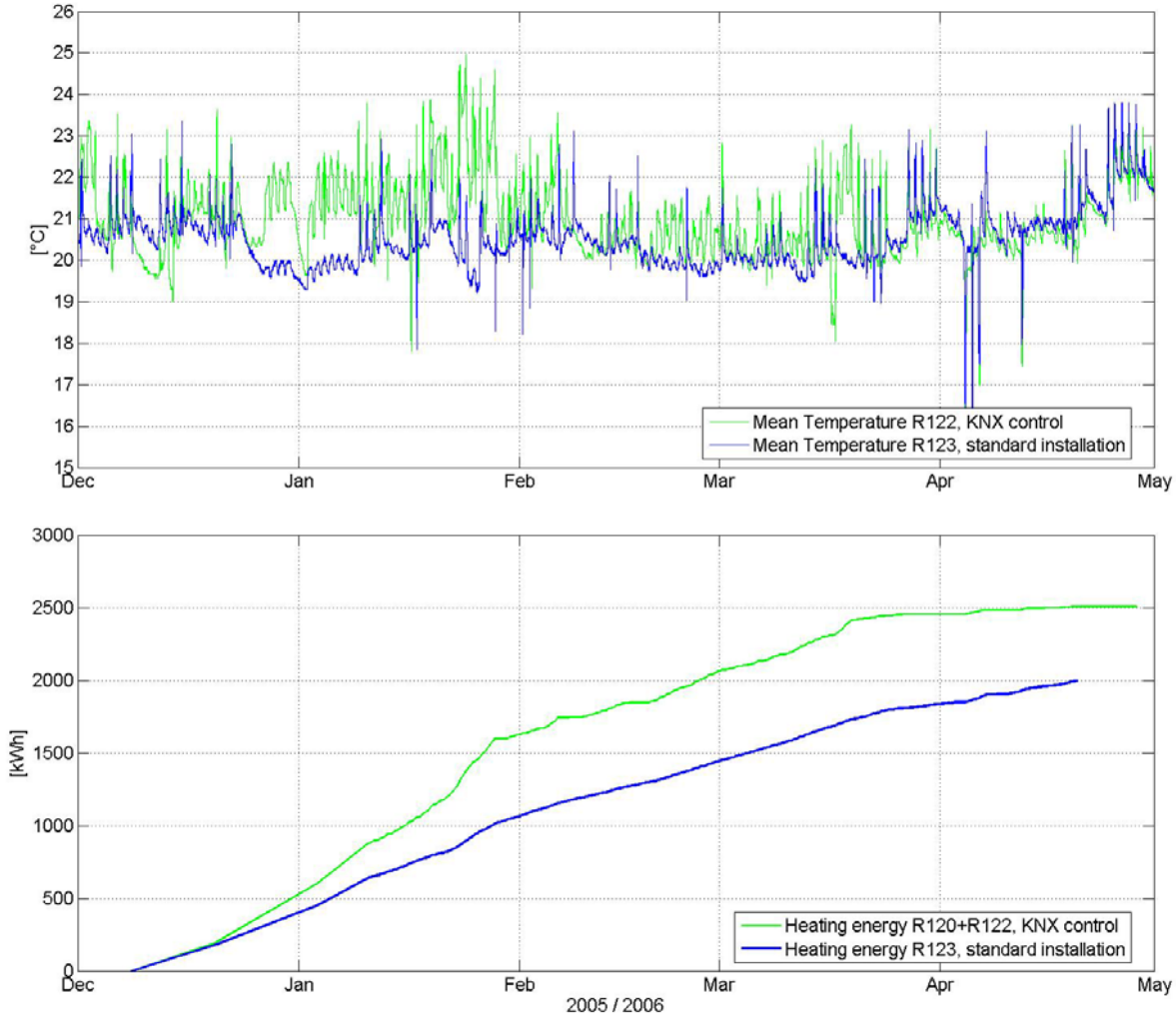

Figure 4: Mean temperature (upper diagram) and heating energy consumption (lower diagram) in the two seminar rooms in winter 2005/2006

The heating energy measurement for the controlled room includes the consumption of the neighbouring lab. It's contribution can only be estimated. In the first 3 years it was not used regularly but since 2005 regular classes and project work took place in the lab. From time-tables and from the measurements it was found that a share of about 30% of the heat meter measurements can be attributed to the lab since then. For the comparison of the two seminar rooms this means that in fact 50% energy savings are gained from individual room control without compromising user comfort.

The main sources of these savings are more accurate room temperature control (no unnecessary heating), and the closing of the valves when windows are open. The latter was studied experimentally in the room with standard thermostats. Figure 5 shows room temperature decay and heating energy consumption with open windows on a winter day. Since the radiators are located directly below the windows, the thermostats fully open the valves and heating energy consumption rises significantly.

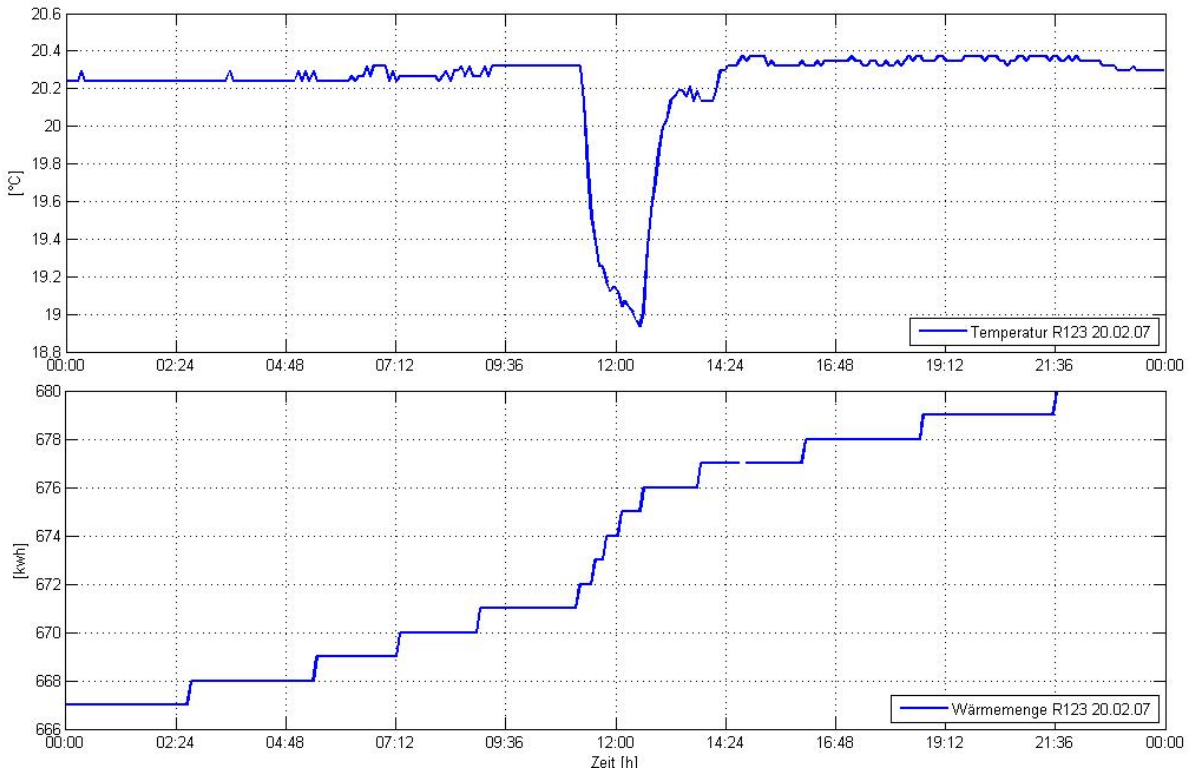

Figure 5: Heating energy consumption with standard thermostats while windows are open

In educational buildings windows are opened regularly after classes. If the room is not used afterwards they will often stay open for several hours. Losses from these situations sum up to a very significant part of the overall heating energy consumption.

Apartment buildings – a field test

Another study carried out by Bremer Energie-Konsens and the Bremen Energy Institute evaluated wireless centralized room temperature control systems [5]. In a preparation phase six buildings of a housing society were chosen as three pairs comparable in size, thermal protection standards and inhabitants. Three buildings – one of each pair – were equipped with new room temperature control systems while the others served as a reference in the evaluation. In 72 apartments (more than 90%) of the three buildings the standard thermostats on the radiators were replaced with new electronic thermostats and a central control unit (Techem System Assisto). The thermostats allow for more accurate temperature control and can be parameterized from the central unit via wireless communication. This way, nominal temperatures can be set for each room with a time schedule. Energy savings of up to 20% were expected from this new control system.

The heating energy consumption of the previous years and after installation of the systems from November 2004 to October 2006 was measured and analysed. For each building previous and new values were compared. Temporal effects and weather conditions were compensated in this comparison. Additional comparisons were done with the three reference buildings with standard installation. Interviews with the residents also assisted in the evaluation.

After the two year measurement period the analysis of these field test data showed no systematic decrease in heating energy consumption. No significant difference in heating energy was found between the buildings with the new installation and the reference buildings or the same buildings in previous years.

Several possible reasons for this unexpected result are considered in the study. They relate to

- the resident's awareness and attitude,
- system complexity and
- technical competence of residents.

Residents had already achieved considerable energy savings in the previous years. Several thermostats had permanently been kept off to save energy costs. This potential could not be accessed any more by the new system.

Only about half the installations were operated in an appropriate way. Thermostats were controlled manually and didn't use the central unit. Despite the fact that all residents got detailed information and advice how to operate the systems only a small number was parameterized according to the instructions.

The study recommends simplification of user interfaces and to reduce the number of operation modes and possibilities of user interaction.

Conclusion

The different results of the two studies underline that estimating the energy savings potential of a building requires detailed analysis of the given building, it's use and it's users. User behaviour is a major influencing factor. To what extent awareness of energy issues and basic technical understanding can be expected from the residents is an essential design aspect of building control systems. In addition suitable measurements should be chosen for feedback. Thermostats measure the temperature directly at the radiators. This is hardly an optimal indicator for user comfort especially in large rooms.

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