Energy Efficiency @ Home

Today's 'smart home' needs to do more than to provide lighting ambience or multi-room audio and video at the touch of a button. In times of global warming, carbon footprints and ever increasing energy bills, intelligent building control systems also need to make a measurable contribution to the energy efficiency of a modern home.

Did you know that buildings account for over 40% of Europe's total energy consumption today? This figure outstrips energy utilisation in either the industrial or transport sectors. What's more, up to ¾ of all the electricity generated in the EU is consumed in residential and commercial buildings. And the demand for energy in buildings is still growing!

Reason enough for EU governments and policy makers to take the energy performance of buildings seriously. It is estimated that more than a quarter - 28 % - of the energy used in the buildings in the EU could be saved with relatively simple measures. Not surprisingly, energy efficiency in buildings will be a key factor in achieving the EU Climate & Energy objectives, namely a 20% reduction of greenhouse gas emissions and 20% savings in the EU's annual primary energy consumption by 2020.

As residential dwellings account for nearly ⅔ of all energy consumed in buildings, it is clear that our homes are under pressure to become more energy efficient. EU directives to increase the energy performance of buildings now encompass almost all aspects of modern constructions. Everything from the thermal characteristics of the construction materials used or the mandatory contribution of renewable energies up to the energy efficiency of the electrical consumers contained within is taken into consideration.

We all know that a well insulated building with double or triple glazing can make significant savings. Modern heating, cooling and ventilation systems use energy far more efficiently than their predecessors. And purchasing 'A+'-rated white goods, for example, fridges, can show real paybacks when the electricity bill arrives. However, in additional to these established measures, one approach to increase potential savings in buildings is gaining more and more interest due to it's ability to offer integrated, building-wide energy saving solutions – the intelligent electrical installation or so called Smart Home and Intelligent Building Control.

Today, one of the world's leading and most widely accepted intelligent electrical installation systems for home and building control is KNX. In short KNX is a so called 'bus system' in which all the different electrical components in the installation, e.g. wall switches, switching actuators, thermostats, etc, are connected together and communicate with one another via a single twisted pair cable (the Bus). This offers noticeable advantages over traditional installations and allows the optimal, energy efficient interaction of the individual sub-systems. KNX technology offers control solutions for all the applications found in modern commercial and residential buildings, including lighting, heating and ventilation, shading, security, fault monitoring, energy management, central automation and remote control.

Info

What is KNX?

KNX – the Worldwide STANDARD for Home and Building Control

- an intelligent installation technology for the integrated control of all electrical applications found in modern buildings
- a common and open technology platform supported by more than 220 international manufacturers worldwide with compatible and inter-working products
- the world's first standardised home and building control system according to ISO/IEC 1453-3 / EN 50090
- a system supported by thousands of trained professionals worldwide
- a robust technology with over a two-decade-long track record in thousands of projects from private houses to office complexes all over the world

Smart home and intelligent building controls are already widely used in many of today's commercial buildings and infrastructure projects worldwide. They play a significant role in making the buildings in which people work and live more flexible, secure, convenient and economical. Their utilisation will spread more widely as new legislation forces designers to comply with energy saving regulations, such as, the EU standard EN 15232 Energy Performance of Buildings - requirements that generally can not be met using traditional electrical installations techniques. Scientific studies as well as countless, real-life reference installations have clearly shown that double-figure savings in energy consumption in commercial buildings can be made with KNX intelligent building control.

However, to what extent can energy be saved in residential houses? Considering the very different requirements and usage profiles of the two types of buildings can intelligent building control bring real paybacks? Can the typically contradictory requirements of comfort and energy efficiency be fulfilled simultaneously? To help us investigate this matter further, we will use a real-life reference object to demonstrate and evaluate some of the energy saving functions that can be integrated into a smart home with KNX intelligent building control.

The object of scrutiny

The building in question was completed in December 2007 and is now the residence of the family Schmidt. The detached house, in a traditional city-villa style, has two floors and a cellar with around 300 m² of living and utility floor space. Requiring a maximum theoretical calculated 99 kWh/m²a of primary energy according to the relevant construction standards, the building substance already possesses relatively good thermal isolation and energy loss values. Primary heating is provided for by under floor heating using the latest re-condensing gas-boiler technology with semi-insulated roller shutters adding to the thermal protection measures of the building.

Mr Schmidt, being a technical enthusiast, was already convinced about the benefits of intelligent building control and as such it was clear from day one that the house installation would be using the full capabilities of KNX. During the conception and realisation of the project, the topic of how to save energy costs using KNX but without sacrificing functionality was a constant dilemma. Both the design of the installation and the final commissioning were carried out by Mr Schmidt himself, allowing him to experiment with and optimise the automation features.

The energy efficiency principles implemented with intelligent building control in this project are as straight forward as they are effective.

1) Use energy only when required, e.g. presence or demand activated control of consumers

2) Use only that amount of energy that is actually needed, e.g. regulating temperature, daylight harvesting

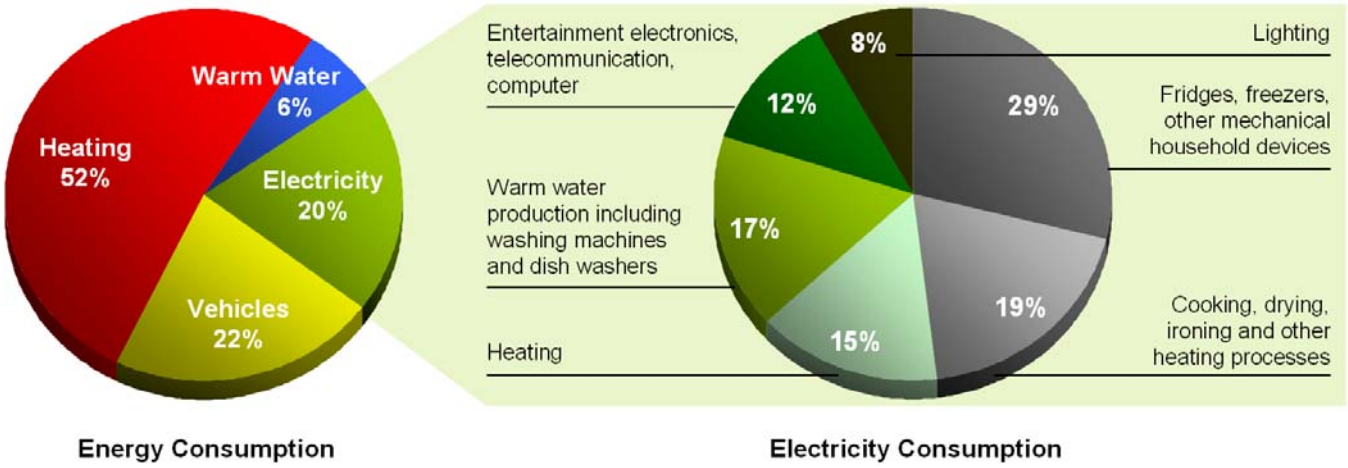
3) Promote 'desirable' and minimise 'undesirable' external factors affecting the energy balance of the building, e.g. automatic shading, control of solar gain

Staying warm ....

The first step in contemplating how to save energy is to know where the energy is being consumed in the first place. The statistics in the graphic below show how energy is used in a typically household. It is probably not surprising that by far the most energy is used for heating and hot water production. Let's look at how KNX intelligent building control can help to reduce this value.

KNX thermostats - the key to energy efficient room temperature control

The key to saving energy with the heating is having the minimum, comfortable temperature only in those rooms as and when required. As a consequence individual room temperature regulation linked together with central control functions is a necessity. In this case the job is made even easier with the use of under flooring heating. Firstly, by running at lower temperatures than traditional hot water radiator systems, unwanted thermodynamic system losses are reduced. Additionally, as the warmth is *radiated*



How energy is consumed in a typical household - the key to identify potential savings
(Source: BDEW – Federal Association of Energy and Water Management

An unbeatable double act - KNX electronic actuators controlling ...

from the building itself, warming the feet first, a comfortable room environment can be generated at room temperatures that are typically 2 degrees lower than classical systems. An estimated energy saving of around 10% right away!

Each room in the house is equipped with a KNX thermostat allowing the local temperature to be regulated according to the room usage. The heating requirement is transmitted to KNX actuators that in turn control the electro-thermal valves in the heating circuits. Based on the 'demand' created in the heating circuits, the boiler then automatically regulates the temperature of the supply feed and its pumps speeds accordingly. The result is stable, controllable room temperature with minimum energy expenditure - primary and electrical.

... low power, energy saving valves in the heating distribution cabinet

A few additional automation features round off the energy saving application, for example. Between 10 pm and 6 am the main boiler is turned to standby resulting in a natural night time cooling. During this period, or any other time that the boiler is not in operation, all control signals from the KNX actuators to the valve drives are also disabled. This alone saves around 60 kWh p.a. compared to conventional electrical thermostat solution that continue to power the valves. For periods of longer absence, e.g. holidays, the thermostats are all centrally controllable via the main control panel. One push of a button puts all the thermostats into standby mode dropping the room temperature by 3 - 4 degrees during the period of absence.

.... and keeping cool

Maintaining, the right room climate energy efficiently is not just a question of the heating system. Modern residential buildings depend greatly on the integrity of their thermal isolation and the ability to use solar gain in a beneficial way. The theory is great; however, in practice one constructional feature of any home presents us with a dilemma - the windows.

Obviously, ensuring sufficient fresh air enters the house is necessary for a number of important reasons. However, keeping windows open for unnecessarily long periods of time while heating does nothing for the household energy bill. Although KNX can perhaps not alter personal habits it can certainly help us to remain aware of where windows have been opened. In family Schmidt's house each window is fitted with a reed contact and monitored over KNX. This status information is not only used for the alarm system when the family is absent, but also displayed on the control panel for an instant visual reminder - window open!

The second aspect of how windows can seriously affect our energy balance is that of solar gain. Simply put, by letting solar energy in during cold periods to support the heating system and keeping the sun out when the house is in danger of overheating, we can sustain a comfortable room temperature and reduce energy consumption. This is where external blinds and shutters come into there own.

Family Schmidt installed KNX controlled shutters throughout the house. In addition to comfortable manual control of the shutters in each room, either individually or in groups, KNX allows the realisation of sophisticated, energy-saving shutter automation. Using a so called shutter control unit, the shutters in each facade of the building are controlled as one to optimise solar gain.

Using a combination of the house's GPS coordinates, the alignment of the building and the local time, the exact position of the sun is calculated and thus the momentarily illuminated facades. Together with sensor data regarding brightness levels and the inside and outside temperatures, the shutters are automatically moved to preset positions either to let in the sun's warmth or screen the sun's rays while ensuring ample light fills the rooms.

Sun worshipers - the Shutter Control Unit and Weather Sensor

As the sun moves around the building during the course of the day, the control unit reacts accordingly, only activating those shutters needed and thus guaranteeing that a maximum of natural light enters the house. In summer, the result is not only pleasantly cool room temperatures, but also comfortable light levels without the need for artificial lighting. On sunny winter days - with the shutters up - the solar gain effect is clearly perceptible.

A third and final point that is worth mentioning regarding windows is the generally lower thermal isolation value compared to the isolated walls. Once again

Automatic shading - outside exact positioned roller shutters, inside cool and light

automation of the shutters can help to reduce thermal losses from windows, especially during cold nights. Using a KNX twilight sensor and a user defined time program, the installation guarantees that all shutters are closed and opened in line with the Schmidt's daily routine, but also to optimally retain warmth in the house.

The examples given show the real advantages of the intelligent building control. Not only can KNX optimise the efficiency of the individual systems, the integrated and interactive automation brings additional savings and tangible levels of comfort. Presently, the Schmidt household consumes an equivalent of 17.000 kWh p.a. for heating and hot water. This represents a primary energy consumption of 57 kWh/m²a, almost half that detailed in the original energy balance calculation.

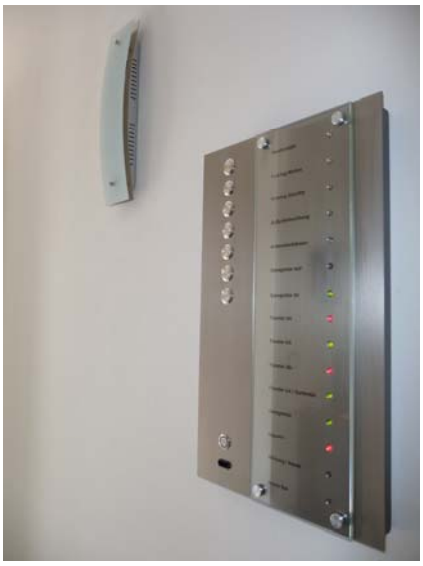
Where's my electricity going?

As in most homes the biggest electrical consumers tend always to be the major white goods that either need to run 24 hours a day, e.g., fridges and freezers, or devices employing energy intensive processes, for example, washing machines, tumble dryers or dish washers. Mrs Schmidt made sure that only A+ rated devices were installed, running them on the 'eco' settings whenever possible. This certainly can make a significant difference in the yearly electricity consumption.

Keeping track of consumption - remotely readable KNX Meters

Regarding consumption, Lord Kelvin once stated, "if you can not measure it, you can not improve it." Measuring consumption may not directly save energy, but adding transparency certainly does make you start to think about how you could you use less. Mr Schmidt wanted to know exactly how much the intelligent building control and other electrical infrastructures in the home were using and installed a KNX electricity meter to monitor their consumption. The values are sent over the bus to a web-based internet controller, where the data is collected, graphically displayed and viewable over any web browser. At the time of writing the KNX, IT and communication infrastructures account for around 20% of the total electrical consumption.

But what about the other household consumers mentioned in the breakdown of household electricity consumption



The control panel - intuitive and aesthetic operation of all central functions

mentioned on page 2, i.e., the lighting, the communications and entertainment electronics? Can KNX help to reduce their contribution to the total energy bill?

Always in the right light

First let's take a look at what the intelligent building control does for the lighting in this house. KNX offers multiple control features for creating great home lighting ... and at the same time increasing comfort and efficiency. At the Schmidt's all the major rooms have dimmed lighting. Not only does this allow them to easily create different light scenes, for example when watching a film in the living room or taking a relaxing bath *en-suite*. It makes sure that just the right amount of light for the activities at hand can be generated and hence the minimum energy used. Using best-practice lighting design principles to get the most out of the luminaries themselves and 'eco'-friendly, energy saving lamps, electrical consumption was further reduced.

In the corridors, stairwells and guest toilet, the lighting is controlled by KNX motion detectors. This not only makes life easier and safer, it also makes sure lights are not left on accidentally. In the upstairs landing the light levels are even automatically dimmed down during the night such that the trip to the bathroom does not become a 'blinding affair' when the motion detector signals movement.

Lighting circuits that have the potential to be left on because they are simply 'out of sight', e.g., outdoor lights or in the attic, are either motion controlled, programmed to automatically turn off after a predetermined time, or are turned off with a central broadcast command at 2:00 am. If for some reason the lighting should remain permanently on, a long press of the relevant KNX light switch (>3s) temporarily deactivates this energy saving feature.

Last but not least, before leaving the house, a central off button on the control panel allows all lighting - and any other electrical consumers that should not be on, e.g. kitchen devices, etc - to be all switched off. Isolating certain electrical circuits in this way can help reduce possible fire risks in the event of an electrical fault. And without doubt, it certainly prevents electricity being unnecessarily used by forgotten 'left-on's'.

Fighting stand-by consumption

The Schmidt's are big electronics, computer and multimedia fans. Not surprisingly, most rooms are equipped with audio-video and PC components. As with many modern electronics, these devices consume not only when they are being used, but also when they are apparently off, i.e. in standby. The consumption of each individual component itself may be small, but adding these up together over the course of a year can result in a surprisingly large figure. One solution would simply be to unplug the units at the wall socket every time after use or switch them off at the mains switch – if indeed they have one. Needless to say this is tiresome and mostly unpractical; hence the devices tend to be left on standby.

A clear advantage of KNX is the ability to easily integrate switchable socket outlets into the home control solution. This makes turning on and off one or more portable or rather pluggable consumer as needed child's play. In our reference object, each major room in the house is provided with a minimum of two switchable socket circuits, to which any socket outlet can be freely assigned. The sockets can be comfortably controlled either over the local KNX switch sensor, via remote control, e.g., iTouch or over the web-based visualisation. Considering the equipment inventory in the house, this helps eliminate an estimated 500 kWh per year of unwanted standby consumption costs! Furthermore, as the devices are isolated from the mains supply when not supervised, not only is

The communication headquarters - internet, telephone, and multimedia

The meaning of 'Smart Home' - the symbiosis of design and automation
(Photo: LED facade lighting - motion, time and light level controlled)

the fire risk reduced but to a certain extent additional over-voltage protection is also provided.

In order to support the internet and multimedia requirements such as audio and video streaming, the house was installed with a structured, gigabit IP network. At the heart of this installation are the IP system components, i.e., multiport switches, the DSL modem and the network attached storage (NAS) with integrated multimedia server. These devices consume 20 to 40W depending on network activity. A central KNX logic monitors the status of all the components and consumers in the house, including designated socket outlets, which require an IP service. If one or more of these are activated, e.g., a PC is turned on or a KNX fault signal in the form of an e-mail needs to be sent out, the network is automatically turned on. Vice versa, as soon as no service is required, the network simply shuts down again. This measure contributes to around 120 kWh per year of prevented energy wastage without loss of function.

Considering all the energy saving functionality that has been integrated into the electrical installation, the question begs to be asked - what's the result? The Schmidt's consume on average just less than 3000 kWh a year. This is little below the statistic average for a 2½ head family living in a detached house. However, perhaps more relevant is the fact that the family's pervious consumption value in a 2 bedroom apartment was also around 3000 kWh p.a. The conclusion is that KNX intelligent building control has clearly increased the comfort, liveability and security of the property and at the same time, as a result of the energy saving measures, compensated any additional consumption as a result of the superior infrastructure and functionality. Or put simply: more for less!

Will there be anything more Sir?

In addition to the many energy saving functions that have already been mentioned, the KNX installation looks after a whole range of daily tasks for the Schmidt's making life easier, safer and a bit more fun.

- Security: in addition to intrusion monitoring with window contacts and motion detectors, the KNX alarm system also includes detectors for important technical dangers such as water ingress, gas leakage and smoke detection.
- Fault monitoring: the electrical installation and heating system are monitored and any incidents reported.
- Automation: a central time schedule controls all the routine functions in the house according to the day of the week and if the house is occupied
- Remote control and visualisation: via WLAN and the KNX IP router and internet components, control and visualisation of the installation is possible from any web browser capable device in the house.

Summary

The KNX based smart home and intelligent building control technology used in this project has clearly shown that it is indeed possible to increase the comfort, security and functionality of a residential home and at the same time make tangible energy savings. For the family Schmidt, the house is a dream come true. Not only has their quality of life improved, the monthly energy bills are also now less of a burden.

For further details regarding the KNX system and the ABB i-bus® KNX range of products used in this project or the KNX organisation and community please refer to the following internet sites:

http://www.knx.org

http://www.abb.com/knx