Abridged report
Interface human - building services engineering

31.05.2008

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The project report was advocated with measures from the „Bundesamt für Bauwesen und Raumordnung“. (Aktenzeichen: Z6- 10.08. 18. 7- 06. 20)

Abridged report:

1. Intention of the research project

The research project “Interfaces human - building services engineering” describes guidelines for the improved design of the interaction of the user with the building services engineering. As a result references should be given, how intuitional operated control- units should be designed, in order to avoid operating errors and thereby energy wasting. Furthermore young and old, as well as changing habitants and users shall be in a position to receive a desired indoor temperature by easily interpretable setting parameters. Therefore the parameters of heat, aeration, light and shadow are considered. These parameters were analyzed for the domains of habitation, habitation for a definite duration – hotel, bureau - working as well as bureau – conference and according approaches are developed.

In this context references and ideas for improvement concerning the design, the placement and the application of these units shall be given. In addition it seems to be sensible, to refer information and recommendations of behavior to the users, such as “close the window”, “switch off the light” etc., to encourage energy- saving behavior. In this context we also analyze, which setting parameters can illustrate the desired criteria of comfort. It is reasonable to give references to the user concerning the energy consumption and the possibilities of energy- saving if possible already during the setting of the control- units.

The references are elaborated for a user group as big as possible. We do not treat the human- machine- interfaces which allow the setting and optimization by abstract parameters to professionals like janitors, building managers and energy provider. The focus is rather the interface between “layman“ and machine.

We are looking for standards for the basic functions which prove themselves in the practice and which have a high value of recognition.

2. Procedure of the research project

Research

The on-site inspection in selective buildings and the practical experience show that the currently available controllers and actuators afford a multitude of possible settings often based on highly abstract parameters. Their interpretation is asked too much of the ingenuous user. It is reflected in practice that even expert staff is overstrained with the calibration of different facilities (heating, ventilation) because many conditions must be considered and the facilities allow only limited mutual influence.

Even when being structured in useful fields of application, there is still a plurality of switches and ways to use, whose number is still increasing with the technological development. Thus operating agents grow more and more powerful in their flexibility and possibilities of adjustment, but also more complex and hence difficult to understand for the user, whereby the acceptance of a bigger part of the users decreases. Useful adjustments are being omitted or even adverse parameters are chosen by mistake.

It is to be declared that despite of the numerous possibilities of adjustments which the existing operating agents offer, it is often impossible to adjust directly the aspired value of comfort, but there is rather an abstract physical value like a flow rate or just a non-dimensional number available.

Within the technological development in the field of microelectronic, especially in the fields of control, adjustment and data communication emerged numerous possibilities of automation and control by making use of logical connections. Those, by the number of connected situations exponentially rising possibilities lead to excessive demands for many users while adjusting their technical facilities energetically optimized. The apparent win of comfort can thereby reverse into a heightened potential of spoiling energy. In the approaches for a solution, there was paid great attention to making maloperation almost impossible and to create an awareness of energy consumption in the user.

In order to receive helpful suggestions there have also been analyzed operating agents of the areas of communication and information technology. At the investigated “everyday” hardware, like for example cell phone, digital assistant, navigation system, etc. can be ascertained that the interface between machine and user, under the application of the newest technological possibilities is generally realized via software and a programmable display. This offers on the one hand the realization of different functionality on the same hardware platform and on the other hand this organization structure allows the implementation of multitudinous functions and menu layers almost in numbers at will.

Screenshot of the online-product data base

The analyzed operating agents were registered into an especially created data base and can be sorted and classified after various criteria.

Potential to reduce energy consumption

In this chapter the saving effects are divided into two categories and their potentials are demonstrated respectively.

- Saving effects that arise from automation and central operation.
- Saving effects that arise from altered user attitude.

Some effects of automation and of user attitude have indeed the same virtue, but differ in the way of investment and the independence to changing users. Therefore the saving potentials are described separately in these two categories.

Approaches

From the insight of the analyzed operating agents and relevant norms about serviceability and ergonomics were composition guidelines formulated to fulfill the following claims.

- Standardization

The research proofs the necessary standardization of the minimal basic function to be able to adjust the standard value of comfort (room temperature, luminosity and air quality). The standardization is to contain preferably the fields of symbolism, the way of controlling, the way of display, the way of confirmation as well as the positioning of the operating agents inside the room.

- Demand orientated energy disposition

A mere dependency of time in the control is too inflexible as it doesn't react to changing user terms. Better is for example a control in dependency of presence or measured situation values.

- Relation between user action and energy consumption

The user must once again be able (like it used to be with the wood stove) to establish the temporal and local reference to energy consumption. In addition to the limitation of the potential of spoiling, the new notification of energy consumption will be one of the main requests to the new to be designed operating agents.

Design guidelines

From the insight of existing operating agents for building services engineering as well as such of other machines the following composition guidelines were formulated. Thereby were considered general, but also for the occupancy specified demands.

- All energy consumers (heating, cooling system, light, ventilation for aeration and electricity) of the complete system (building, apartment, user unit) have to be centrally detachable with one operating agent.
- All consumers of the subunits (single rooms, zones of equal use) have to be each centrally detachable with one operating agent.
- When the complete system is centrally detached, the subunits must stay active for some more minutes and give the signal that they will soon deactivate.
- When the complete system is off, it can be switched on again by each subunit.
- The operating control is always attached at the entrance near the door instead of the light switch. It must obtain the function of the light switch.
- All operating controls have the same appearance.
- The operating control requires the switching statuses “present”, “absent” and “off”.
- In the status “present” all energy consumers can be activated in order to achieve the given values.
- In the status “absent” the actual values can departure from the given values within limitation.
- In the status “off” all energy consumers are switched off.
- The statuses “absent” and “off” must be activated automatically (detection of user presence) after a certain time.
- The most important parameters of comfort: temperature, light and air quality must be adjustable separately at the operation control.
- The particular given and actual values must be displayed in relation with each other.
- The span of time until the arrival of the given value must be displayed.
- Excessive energy consumption must be displayed in

two levels. (high / superelevated consumption).

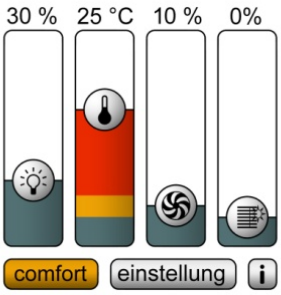
- An energy-saving adjustment must be displayed.
- Energetically conflicting adjustments must be displayed and possibly be avoided.
- Icons are to be preferred to lettering

Icon design

In order to get a statistical coverage 62 persons of different age were interrogated about icons for light, temperature, aeration, sunblind etc. Background of the questioning was the presumption that younger and older persons prefer different icons. Differently designed icons lead to less maloperation and according to that an energy saving effect will occur.

Control element

In the following an exemplary interface will be demonstrated that corresponds to the developed guidelines.



The system is composed of a host, control units that are utilized repeatedly in the building (at least once per room), many sensors and switchable power outlets.

- Power outlets

The power outlets are expanded with an additional function. They can be adjusted by a slide switch to the function “constant on” and “switchable”. Thus important units like the fridge and the telephone system can stay on the power line while unimportant ones like the cooker and standby machines can be switched off centrally.

- Sensors

The sensors measure the values outside illumination, outside temperature, room illumination, position of shadow and window position, amount of fresh air of the aeration and temperature of the fresh air.

- Control unit

By the control units light, temperature, aeration, shadow and the power network are controlled centrally

3. Résumé and prospect

Thinking of the building services equipment at the beginning of electrification the following picture appears:
For the heating of buildings local heat generators such as for example wood-, coal- burning and oil stoves were applied. These facilities had to be operated directly at the apparatus and the user had to transport the energy carrier manually to the place of energy need. Thus the relation between energy consumption and user was highly ensured. Even though those facilities worked highly inefficiently, the potential of energy wasting was strictly limited by the number of users, the availability of the energy carrier and the effort of handling

For these reasons energy was only consumed when there was really a need. The behavior of the users was geared to the given conditions of the time of day and to the season. The described situation also applies to lighting; passive measures prevented the buildings of overheating.

Within the scope of the progressing technical possibilities the availability of energy carriers increased and the building services equipment was automated. The development of building services engineering was driven by the idea of convenience. The optimization of energy efficiency was for a long time besides the focus of the development. Therefore the energy waste potential increased enormously. You can have it warm and well illuminated everywhere and anytime. The only relation of the user to the energy consumption is the billing of the energy costs.

Precisely this relation will contribute in the future by increasing costs of energy to more awareness to the energy consumption and it will create the wish of energy saving at the user. The up coming control elements have to support the user in this ambition by indicating information about the consumption.

Moreover intuitionally operated control elements have to be designed to allow to the user to set clearly the desired parameters of convenience and to visualize the influence on energy consumption. Out of that the user recognizes how to save energy.

Future control elements (and the technique behind it) have to be designed to allow to the user the optimal adjustment of the different facilities without estimating any knowledge of building physics or building equipment.

A further step should turn the references established in this project report into prototypes. Those could be installed in a chosen building occupied by different utilizations in order to

record the acceptance of the user to deduce further potential of optimization. In the practice use also the effects of saving can be determined more exactly.

Since a part of energy saving by new control elements is based on central or automated regulation, you have to implant components which consume energy on their part. Therefore the concept of prototypes also has to take care to apply energy efficient technique for intuitional handling of control elements.

The studies mentioned above show a potential of energy saving by automation of 30 % in the domain of heat energy and up to 60% in lighting and electric energy. In practice by energy optimizing the pattern of use an effect of energy saving of up to 20 % in the domain of electricity and 25 % in the domain of heat energy were achieved. These energy potentials can surely not be achieved in an additive way, however they show realizable dimensions. Consequently the development of intuitionally to operate control elements is profitable, because they do not only improve comfort, but also secure from maloperation and encourage the user to energy- saving behavior and support him in energy-saving.

In the context of sustainability of building technical equipment the development of products has to take care that the control elements are designed to cope with the usual durability of building equipment. This concerns the mechanical durability as well as the long term usability of the software. Ideally the systems of facility techniques, control units and control strategies can be adapted easily to new efficient technical developments by standardized interfaces.

In future the user shall be able to set his desired values of convenience and operator modi of efficiency by imagery, the systems engineering cares on its own and in a intelligent way for the optimized application of energy and for the achievement of the situations of convenience. The newly developed control elements are therefore the link between the user- and the systems engineering.