

Integrated Room Automation and Energy Efficiency

White Paper, Version 1.1

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Summary

Heating, cooling and ventilation in buildings currently accounts for around 40% of the global primary energy consumption and causes just under a quarter of the CO₂ emissions worldwide (indeed, 40% in Switzerland or Germany). In the campaign against this environmental pollution, maximising energy efficiency in buildings is of enormous significance.

For **building automation**, the focus is on room automation, because rooms – where energy consumption ultimately occurs – provide the greatest potential for savings.

Integrated room automation deals with all the relevant factors in the room: lighting, heating/cooling, ventilation, humidification, window blinds, user behaviour and so on. The maximum energy saving is achieved (while also maximising comfort levels) through the accumulation and intelligent combination of all the optimising measures.

European standard **EN15232** and German directive **VDI3813** have set down definitions for the relevant functionalities, and EN15232 standardises the energy classes from A to D.

For **SAUTER**, energy efficiency (comfort provided/energy expended) is the primary goal. Our products and solutions are consistently geared towards this goal. We use EN15232 and VDI3813 as the basis and implement their stipulations rigorously.

This **white paper** describes the approaches in detail, and provides the related facts and figures.

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Introduction

Room automation is the term used to describe the electronic controlling and regulation of comfort factors in a room: temperature, brightness, humidity, air quality and so on.

Integrated refers to the comprehensive inclusion of **all** the technical facilities relevant to this, such as: **lighting, heating/cooling, ventilation, humidification, window blinds**, as well as **all** the external factors, such as **outside temperature, solar radiation, usage, user impact**.



Integrated also refers to the integration of the room automation with the central production of **energies** (heat, cold, air) so that they can be controlled according to needs (**demand-led control**).

The main **command variables** in integrated room automation are the maximisation of the comfort of the users **and** the minimisation of the energy expended **in equal measure**, which means nothing other than **maximising energy efficiency**.

European standard **EN15232** sets the benchmarks for energy efficiency through building automation and defines functionalities for **efficiency classes from A to D**.

EN15232 class	Thermal energy		Electrical energy	
	C→B	C→A	C→B	C→A
Offices	-20%	-30%	-7%	-13%
Lecture theatre	-25%	-50%	-6%	-11%
Educational facilities	-12%	-20%	-7%	-14%

Energy-saving potential for non-residential building compared to efficiency class C (reference), according to EN15232 (additional building types in EN)

SAUTER is totally committed to the goal of increasing **energy efficiency**. True to our company slogan ('**Creating sustainable environments**'), all our products and solutions are designed to meet the above-mentioned criteria as completely as possible.

The SAUTER ecos 5 room automation stations integrate **all the functions of room automation in a single device**. The specifications are set so that all the required sensors and actuators can be connected directly.

With its fully programmed **modules** in accordance with **VDI 3813-2** (*room automation functions*), the ecos 5 is able to fulfil all the requirements of efficiency class A.

In the EY-modulo 5 family of systems, SAUTER **consistently** uses the open, manufacturer-independent **BACnet/IP** protocol for communication. This allows all the elements of the room automation system, the plant automation system and the management level to be connected easily, efficiently and without a protocol converter.

Elements of integrated room automation

How they affect energy efficiency.



A *The user*

This is who it's all about. On the one hand. The room automation system takes care of him. Temperature, brightness, humidity, quality of air (oxygen/CO₂ content) and air movements are the decisive environmental factors for his **comfort** and his **productivity**.

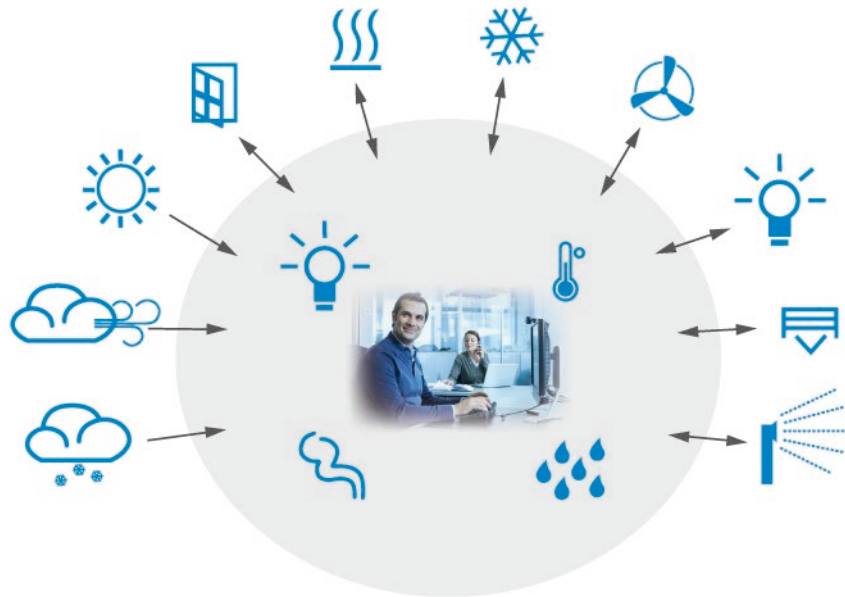
His comfort is the dividend in the formula for energy efficiency!

$$\text{Energy efficiency} = \frac{\text{Quality of the achieved comfort}}{\text{Energy spent}}$$

Apart from the above, the user also affects **the room, the room automation and the energy consumption**.

On the one hand, due to the heat that he himself gives off (and the heat from his workplace), although the room controller automatically compensates for this.

And on the other, due to his behaviour. The ability of the **user** to **control** certain functions (temperature setpoint, lighting, windows etc.) is a comfort feature of room automation. However, in so doing, the user also affects the energy efficiency. For the user to be able to make intelligent decisions, it is important for the system to provide clear and accurate **information** on the effect of his interventions. The system must also ensure that everything is reset to the initial state, if ever the user forgets this.



Facts and figures:

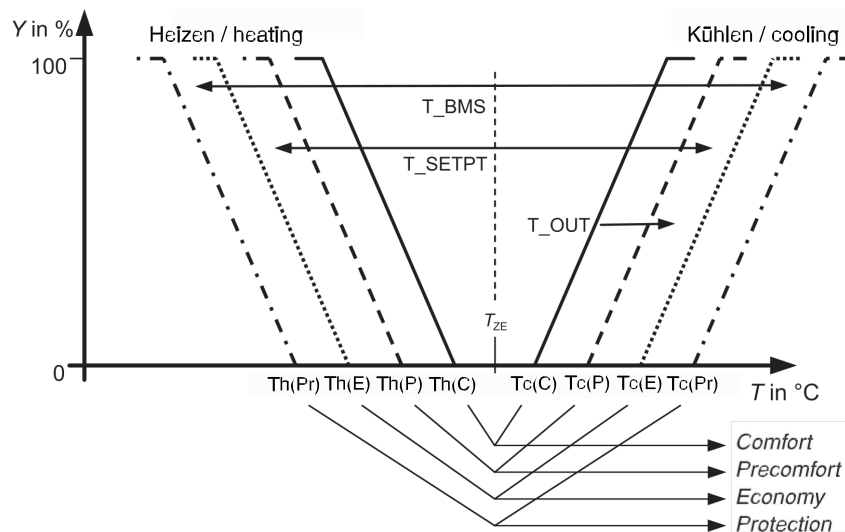
- People's productivity and job satisfaction can be increased by **15%** in an ideal working environment (lighting, temperature and quality of air). Scientific studies, e.g. BOSTI (Buffalo Organisation for Social and Technological Innovation), have been proving this since the late 1960s.
- Productivity decreases by **2.1%** for every degree that the room temperature increases over 23-24 °C. (Shin-Ichi Tanabe, Waseda University Japan)
- Experience has shown that there is an energy saving of around **5%** per °C reduction in the room temperature during the heating period.(SAUTER)
- The energy saving is **5-10%** if the room temperature is increased by 1 °C during the cooling period. (Shin-Ichi Tanabe, Waseda University Japan)
- On average, users give off **80 W** of heat per person into the surrounding environment. This goes up to around **210 W** if the heat loss of a typical PC workplace is added.

At SAUTER:

- With the **ECO¹⁰ LED** (on room operating units of the ecoUnit 3 series), SAUTER provides the user with direct feedback on the effects of his interventions. See section <H Room Operating Unit>

Occupancy detection

Information on user occupancy (**occupancy evaluation, as per VDI3813 - 6.5.2**) is a major source of energy-saving potential, since it enables the comfort criteria (with increased energy expenditure) to be fulfilled only when people are occupying the room. For this purpose, set-points are stored in the room automation station for various **comfort/energy levels** (**according to VDI3813 - 6.5.19**), e.g. <Comfort>, <Stand-By>, <Economy>.



Setpoints for various energy levels (source VDI3813)

Either the occupancy information is recorded by **occupancy sensors** or **time programmes** specify the expected occupancy. The user can also enter his presence/absence himself in the room operating unit. In commercial buildings, it may be possible to detect occupancy (via access control systems) a certain period before a person actually enters the room. With regard to air quality control, occupancy is detected indirectly by measuring CO₂ levels. See section <D: Ventilation>.

Time programmes (or occupancy detection via access control systems) enable the next comfort level to be anticipated and, therefore, activated with precise timing (**Optimised starting as per VDI3813 - 6.5.20**). Occupancy sensors enable the system to be controlled based on the effective occupancy (in particular when the room is vacated, e.g. lighting), thus avoiding unnecessary energy consumption. Maximum energy efficiency results from combining the various occupancy information sources. In this way, brightness and temperature can be adjusted in order to attain the optimal energy consumption levels at all times.

Apart from occupancy, the **type of room usage** (as per VDI3813 - 6.5.3) can also be taken into account in order to optimise the comfort and the energy consumption. Predefined **scenes** that can be selected easily, e.g. <Meeting>, <Presentation>, <Office work> are stored in the controls, along with their optimal values for lighting, solar protection etc.

Facts and figures:

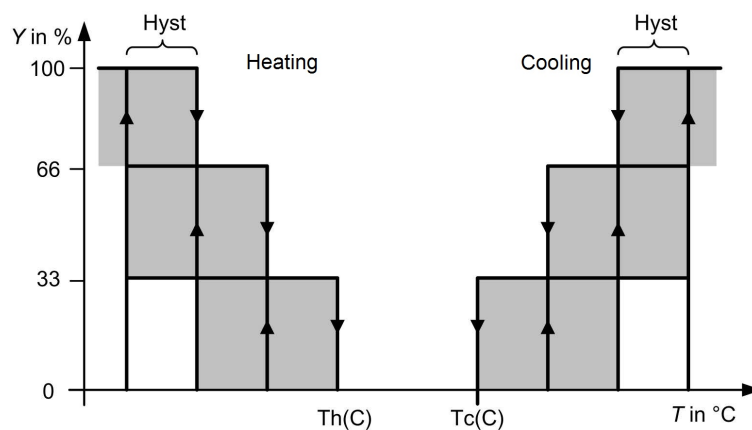
- More than **20%** of heating and cooling energy can be saved in a room with a combination of time and occupancy control. (Wikipedia)
- Up to **10%** of heating or cooling energy can be saved in a time-controlled room. (SAUTER)
- In modern buildings of a light construction, this effect is considerably more significant due to the low energy storage capacity of the materials. (SAUTER)
- **10-20%** is the empirical value for the lighting energy saved for an occupancy-controlled room. (SAUTER)

C Heating/cooling

The heating/cooling of a room is performed by radiators, fan-coil units, underfloor heating/chilled beams, or via the ventilation system.

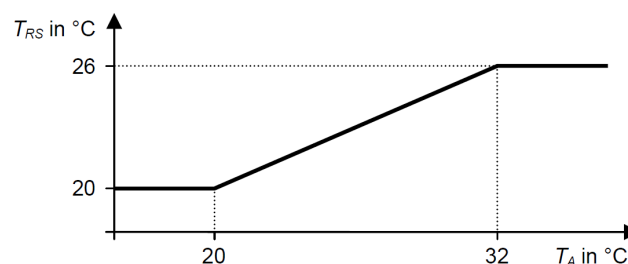
The **quality of control for the heating/cooling facilities** is fundamental for both the users' comfort and the energy consumption. Deviations of all kinds (e.g. hunting, setpoints not being achieved on schedule, unsuitable setpoints) affect the users' comfort and cause them to make incorrect interventions, which can, in turn, have a negative effect on energy efficiency.

With fan-coil units (and also, potentially, with heating/cooling via ventilation) **fan control** (as per VDI3813 - 6.5.25) can be used to optimise the energy consumption by adjusting the fan speed in line with the effective heating or cooling required. When the speed is reduced, the comfort level in the room is also increased by avoiding fan/air noise and potentially unpleasant air movement.



Three-speed fan control (example, source VDI3813)

In cooling mode, the **summer compensation** facility makes a significant energy saving possible. This involves raising the setpoint proportionally when the outside temperature is high in order to avoid an unnecessarily large difference between the outside and room temperatures. At the same time, this also improves the user comfort, because the body has to adjust less to the temperature difference.



Temperature curve with summer compensation

Facts and figures:

- *The energy saving is 5-10% if the room temperature is increased by 1 °C during the cooling period. (Shin-Ichi Tanabe, Waseda University Japan)*

D Ventilation

In rooms with active ventilation, the **air quality control/regulation** (as per VDI3813- 6.5.28) continuously adjusts the supply air quantity to the current requirements. The criteria are: the current user occupancy; a possible defined energy level for the room; and, for the highest energy efficiency class, control based on the effective air quality (CO₂ or mixed-gas sensor in the room). The energy saved results from the heating/cooling and from the power consumption of the fan(s).



In rooms with motor-driven windows/shutters, with fan-coil units with supply-air dampers, or with a ventilation system, the **night cooling** function (as per VDI3813- 6.5.29) uses the (energy- and cost-free) cold air of the night and the early hours of the morning to cool the room. When the room air is cooled, the energy-storing mass is also cooled, and this, in turn, helps to cool the room air during the day. The temperatures of the room and the outside air and, in ideal cases, also the weather forecast data (Meteo module) are used as the basis.

Facts and figures:

- **30%** is the potential energy saving with demand-led ventilation, with air-volume control using a CO₂ or mixed-gas sensor. (SAUTER)
- **10%** is the potential energy saving with demand-led ventilation, with air-volume control using occupancy information. (SAUTER)
- An additional **10%** by optimising the proportion of outside air.

At SAUTER:

- At SAUTER, both the automation station (modu525) and the management level (novaPro Open) have a Meteo module that can anticipate and control the night cooling (and other energy-saving functions). In the reference building, the Exhibition Tower at Basle, the Meteo module and concrete core activation provided very significant energy savings in heating energy (-18%), cooling energy (-32%) and electrical energy (-35%).

E Windows

In buildings where manual window ventilation is possible, **opening the windows** during the heating/cooling period can often lead to a major energy loss. Apart from the direct energy loss due to the outflow of warm/cooled air, thermostat valves or room controllers without connections to window contacts exacerbate the problem by counteractively increasing the heating/cooling output based on the rising/falling temperature. Consequently, and, in particular, in the case of heating with high time constants (e.g. radiators), after the windows are closed again, there is an additional, unavoidable rise/drop in the room temperature (which may cause the windows to be opened again), which further increases the energy loss. For these reasons, room-temperature control with **window monitoring** (*as per VDI3813 - 6.1.3*), which automatically stops the heating/cooling when the windows are opened, is a very useful function. The option of opening windows manually is a comfort feature. Room control with window monitoring makes this energy-efficient.

Facts and figures:

- **10%** is the empirical value for the saving in energy that can be achieved with window monitoring. (SAUTER) In buildings of a light construction, this increases due to the reduced storage capability.

F Window blinds

The aim of the **automatic shading** control of the window blinds (*as per VDI3813 - 6.5.14*) is to protect the room user(s) automatically from blinding or irritating sunlight, whilst simultaneously making full use of the daylight available. If a certain radiation intensity is exceeded, the window blinds are moved to a set anti-dazzle position. When the radiation intensity drops again, they are automatically opened again after a delay, thereby causing a reduction in the proportion of artificial light (via the constant light regulation/daylight switching).

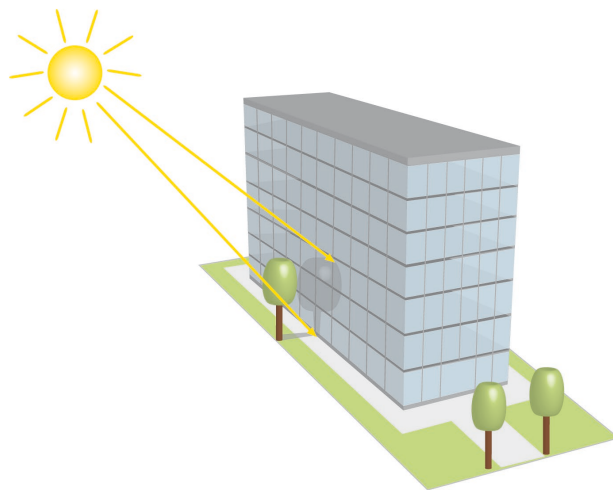


Slat adjustment (*as per VDI3813 - 6.5.15*) is an improved variant of automatic shading that is possible with window blinds/room automation stations that allow infinite adjustment of the slats (e.g. SMI window blinds). In addition to the position of the window blind itself, the position of the slats is adjusted periodically to the brightness level, which provides optimally-adjusted, pleasantly-diffuse lighting conditions, while also saving the maximum amount of energy.

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Shading correction (as per VDI3813- 6.5.16) further optimises the automatic shading/slat adjustment. This involves taking into account the shading from e.g. surrounding buildings or parts of the building itself when controlling the window blinds and slats, and the position of the window blinds is adjusted accordingly. The energy saving results from the improved utilisation of the daylight and consistent reduction of artificial lighting, and from the cooling effect.



In all of these cases, the **user** always has the option of opening or closing the window blinds **manually** according to the demands of his current task (unless the wind speed is too high). When the room is vacated, or after a specific period of time, the room automation system automatically switches back to automatic mode. This effectively prevents storm damage due to window blinds being left down overnight.

If the room is unoccupied, **automatic thermal control** (as per VDI3813 - 6.5.17) optimises the amount of light/heat admitted in order to maximise its contribution to the heating/cooling. Solar protection is also used effectively to increase the insulation of the façade.

Facts and figures:

- *Up to 8% of lighting energy can be saved by using shading control. (SAUTER)*
- *An additional lighting energy saving of around 10%-13% can be made by automatically adjusting the slats. (Wiki/SAUTER)*
- *In an integrated system, the combination of automatic slat adjustment and constant light control can reduce the overall energy requirement to almost a third. (Under ideal conditions in rooms with a good supply of daylight.) An enormous reduction in the energy required. (SAUTER)*

At SAUTER:

- *When the cooling mode is active, and if it is appropriate, automatic shading and slat adjustment in a SAUTER system additionally prevents heat radiation from entering the room. In this case, the window blinds are closed over and above what would be required for dazzle protection. Sometimes to the extent that artificial lighting is required to illuminate the room. In this case, the energy saved on cooling considerably exceeds the additional lighting energy used.*
- *At SAUTER, the light/heat radiation admitted can even be anticipated and controlled accordingly based on the weather forecast data of the integrated Meteo module.*

 **Lighting/brightness sensor**

By measuring the room brightness (brightness sensor/multi-sensor) and using dimmable lighting, it is possible to achieve **constant light control** (as per VDI3813 - 6.5.10) in the room. It enables energy-efficient adjustment of the artificial lighting to the required brightness level, while also optimising the utilisation of the available daylight (depending on how it is being used).



An approximation of constant light control can also be achieved with non-dimmable lighting (possibly adjustable in steps). This is known as **daylight switching** (as per VDI3813 - 6.5.9).

Rooms which extend back a long way and have a varied incidence of daylight are equipped with **multiple groups/rows** of lights. The brightness differences in the room can be balanced out by parameterising an offset to the main setpoint.

In an integrated system, the **combination** of constant light control/daylight switching and automatic slat adjustment (see below) provides enormous reductions in the energy requirement.

In rooms without a sufficient supply of daylight (corridors, bathrooms, storerooms etc.), **automatic lighting** (as per VDI3813 - 6.5.8) optimises the consumption. The lighting is switched on only when the occupancy sensor detects that there are people in the room.

Outside the building, **twilight detectors** (as per VDI3813- 6.5.11) generate the optimal positioning values for the lighting depending on the current brightness outside (brightness sensor).

Facts and figures:

- **10-20% energy-saving potential if the lighting is activated based on occupancy detection.** (SAUTER)
- **45% energy-saving potential through daylight switching in combination with occupancy detection.** (Wiki) (SAUTER)
- **50% and more light energy can be saved through constant light control in combination with occupancy detection.** (Wiki) (SAUTER)
- *The energy-saving potential through automatic lighting is based on the utilisation pattern for the actual room.*

Room operating unit (temperature sensor)

As its name suggests, the room operating unit is the **user interface** to the room automation system. It also includes the **temperature sensor** for measuring the current room temperature, and possibly other sensors for room humidity and CO₂.



Depending on the type, the **display** shows the current room temperature and other information on the operating status of the room. Again depending on the type, the room-temperature setpoint, the lighting, the window blinds and so on can be **adjusted**.

As already mentioned in section <A: The user>, the option of **user interaction** (temperature setpoint, lighting, windows etc.) is a comfort feature of the room automation system. However, this also allows the user to affect the energy efficiency. For the user to be able to make intelligent decisions, it is important for the system to provide clear and accurate **information**

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on the effect of his interventions. The system must also ensure that everything is reset to the initial state, if ever the user forgets this.

At SAUTER:

- To keep the user informed and motivated at all times, the ECO10 LED (in the room operating units of the ecoUnit34* series) provides the user with a direct display/feedback for the current energy consumption.



A red LED indicates increased consumption of heating or cooling energy, or above-average consumption of electrical energy. Additional symbols in the LCD indicate whether the consumption of heating, cooling or electrical energy is too high:

-  Setpoint shift by user > +2K
-  Setpoint shift by user < -2K
-  Window open
-  Lights on, yet sufficient sunlight

(+/-2K are example values. This value can be parameterised)

A special button on the room operating unit enables the user to return to the optimal energy consumption range. In the process, the system utilises all the natural energy sources available, such as daylight, outside air or solar heat, to maintain the comfort level while simultaneously reducing the energy consumption.

Room controller and energy requirement

The room controller is the central device for all control and regulation functions. All the information in the room is gathered here and used to generate control signals for all the actuators.

The **quality** of the **room comfort** and the **energy efficiency** depend directly on the performance capability of the room controller and the quality of its programming.

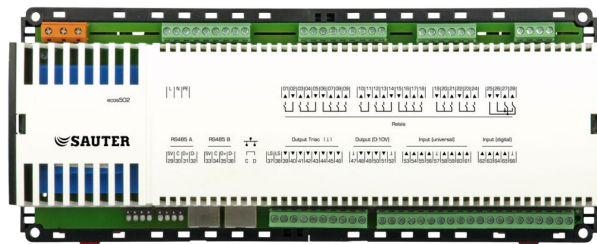
The controller can use the available information to determine the **current energy requirement** for the room (electricity, heat, cooling, air). Along with the attained level of room comfort, this is the **second main command variable** for the room automation system.

The resultant energy requirement is the divisor in the formula for energy efficiency.

$$\text{Energy efficiency} = \frac{\text{Quality of the achieved comfort}}{\text{Energy spent}}$$

At SAUTER:

- The SAUTER ecos 5 room controllers integrate all the functions of room automation into a single device. The specifications enable all the required sensors and actuators to be connected directly, without additional gateways.



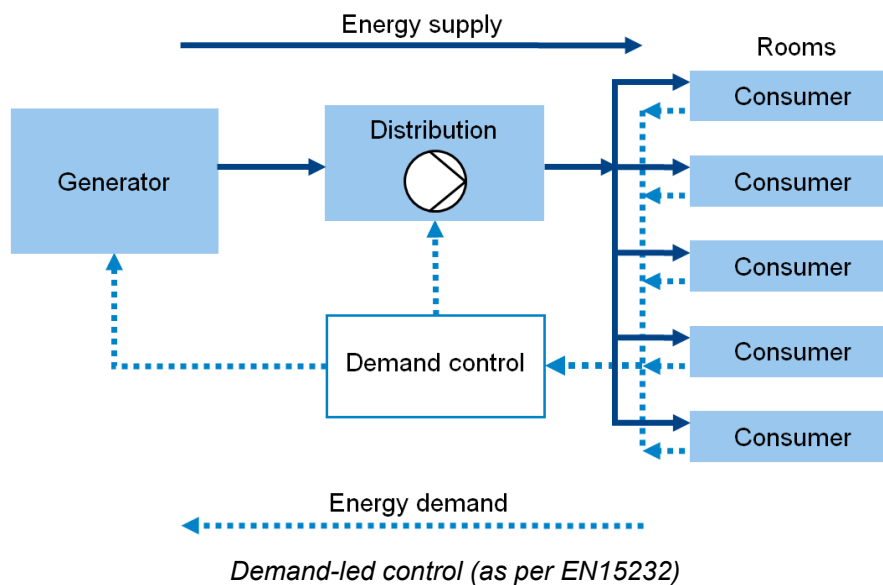
- The room controller can use the energy requirement and other information to calculate virtual figures for the energy expended. Benchmarking with comparable rooms can be used to generate informative and motivating feedback for the users of the room. For example, a weekly energy report by e-mail or a permanent display on the workplace screen can show any deviations from the best possible energy expenditure and help the user to optimise his energy-related interventions/behaviour.



J Communication and notification of energy requirement

Each room controller communicates via (and integrates itself into) a suitable network with all the other elements of the **building automation system**: with the other room controllers, with the controllers of the primary energy conditioning, with the operating and management levels etc.

Of primary importance for the energy efficiency is the communication of the **current energy requirement** for each room controller to the automation stations of the primary systems. From all of these energy requirement notifications, the automation stations can determine the **effective total energy requirement** with the goal of definitely not producing more energy than is actually required (**demand-led control**).



At SAUTER:

- SAUTER consistently uses the open, manufacturer-independent BACnet/IP protocol for communication. Therefore, the elements of the room automation system can be connected easily, efficiently and without any protocol converters to the automation of the primary systems and to the management level.

Conclusion

Of course, the physical construction of a building (insulation, heat-storing properties, utilisation of natural light etc.) provides the basis for a good indoor climate while also enabling high energy efficiency. But the quality of the components in the various technical installations in the building (heat and cooling supply, ventilation systems etc.) is also an important basis.

The **building automation** and the **active energy management**, if they are implemented carefully, comprehensively and intelligently, ensure optimal utilisation and implementation of the given basic conditions.

All three elements – the physical construction of the building, the quality of the system components and the building automation system – make their own contribution towards good energy efficiency. The best possible result is achieved from a sum of all the possible measures.

In particular when restoring existing buildings, investments in building automation are, **from an economic aspect**, the most efficient measures. The improvement in energy efficiency achieved in relation to the capital invested is considerably better than with any other measure (insulating the building shell, improving the existing systems).

SAUTER always provides the right building automation system for every type of building. Whether the building is big, small, old or new. Contact us for detailed advice.

The author

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Company

portrait

As a leading provider of solutions for building automation technology in 'green buildings', SAUTER provides pleasant conditions and a sense of well-being in sustainable environments. SAUTER develops, produces and markets energy-efficient total solutions and offers a comprehensive range of services to ensure that buildings are operated with optimal energy usage. Our products, solutions and services ensure high energy efficiency throughout the entire life-cycle of a building, from planning and construction through to operation, in office and administrative buildings, research and educational establishments, hospitals, industrial buildings and laboratories, airports, leisure facilities, hotels and data centres. With over a century of experience and a track record of technological know-how, SAUTER is a proven system integrator, with a name that stands for continuous innovation and Swiss quality. The recipient of awards for the best automation system and the best energy service, as well as eu.bac and BTL certifications, SAUTER provides users and operators with an overview of energy flows and consumption, enabling them to track the development of their costs.

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