VENTILATION SYSTEM PERFORMANCE

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Paper 1

INTELLIGENT BUILDINGS - INNOVATIVE TECHNIQUES FOR THE ENVIRONMENT

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SYNOPSIS

All around the world the quality of the air is steadily decreasing on account of the strong nuisance caused by combustion deposits. This process is accompanied by a distribution of pollutants occuring even in the highest atmospheric layers due to air traffic. Additionally, the amount of chlorofluorohydrocarbons increases, ozone is produced by photochemical oxidants, and the dust load is growing on account of traffic, industry and domestic heating.

Caused by the relatively high concentration of carbondioxide in the atmosphere, the greenhouse effect leads to climatic changes. Acid rain is produced on account of the increasing exhaust of noxious gases, such as SO_2 and NO_x, which additionally are under founded suspicion of being responsible for the dying of the forests. Causing a strong nuisance to the respiratory air, unburnt hydrocarbons are carcinogenic and lead to allergies.

Independent of this situation, people are more and more aware of the restrictedness of fossil fuels and realize that the conservation of natural resources by comprehensive energy savings will represent one of the essential and most challenging tasks of the future.

The pressure generated by this development is currently leading to fundamental reorientation in all areas which contribute to the strong environmental impact described above. Besides industry and traffic, the domestic area plays a role in this process which should not be underestimated. The end use of energy for heating and hot water amounts to approximately 22% of the overall energy consumption. This value is applicable in the Federal Republic of Germany where heating consumes an important part of the domestic energy supply. In our latitudes, the portion of the energy required for domestic heating amounts to 80% of the energy totally supplied to the average home. In Southern European countries like Italy, Greece, or Spain, these values are certainly different.

With respect to architecture and building materials, this reorientation process has led to advanced technological developments designed to achieve a reduction in the consumption of resources for heating purposes. There is a general trend to reduce the heat loss caused by a transmission through walls and windows. Today, triple glazing and well-insulated walls are used to cut the heating energy demand. On a medium-term basis, the transmission loss might be reduced by approx. 70% so that an average energy consumption of 50 kWh per m^2 and year might possibly be attained in the future. Compared to the present situation in Germany with average values of about 150 kWh for the existing building stock, a reduction by the factor three seems to be achievable within a few years, from technical as well as from economic aspects.

If we assume the ventilation loss to remain stable, its portion in the overall heat consumption would rise from about 20% today to 50% or more, depending on the air exchange rate, in the future [1]. This clearly indicates that ventilation in general, as well as the ventilation loss, will be of increasing significance with respect to domestic heating and the enrgy balance of buildings. Therefore, special emphasis must be placed to this development even now.

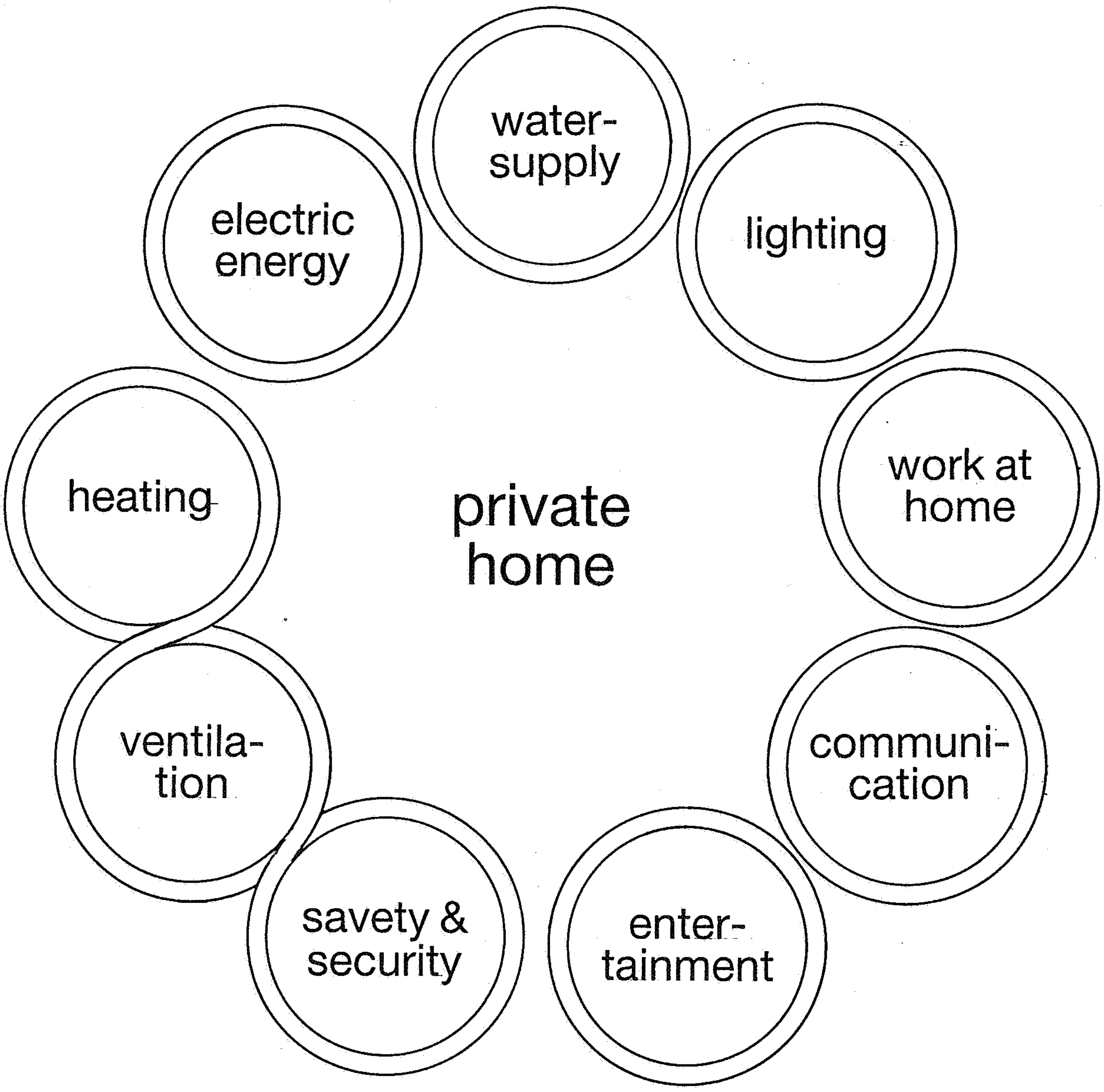
Parallel to this tendency in the field of heat supply which also concerns building materials and their architectural application, various developments in the electronics sector currently being performed will definitely lead to an extensive use of information technology and communications in building design and construction. The performance capacity of modern communications structures is steadily increasing whereas their costs are going down. On account of this process, automation systems which have already been applied to building automation will improve with respect to their level of utilization and, thus, gain acceptance in the private sector on account of the favourable cost development. On the basis of these systems several areas, such as heating, ventilation, lighting, communications, safety and security, will be demand-optimized within the scope of different partial processes. Responsible for the individual areas, the integrated computer intelligence ensures that the supply is optimally adapted to the actual demand. Additionally, considerable advantages result from synergetic effects and the possibility of easily installing the communications medium.

1. INNOVATIVE TECHNOLOGY

New approaches show that future processor systems will be cost-effective and highly efficient. Being already utilized in automated commercial buildings, such systems will soon be modified in order to be suitable for residential buildings or even apartments. In this case, the benefits of such systems would also become effective in the private sector.

Today, even small and inexpensive microprocessor systems are capable of planning and processing demand-oriented automation strategies. The basis of this development is a communications system technologically accomplished in the form of a bus system. Moreover, 'intelligent systems' have to be developed, controlled by microprocessors and capable of being mutually connected via the communications system. Then, the first connections between such systems will be established to achieve automation of partial areas. The final objective consists in the optimization of heat and fresh-air supply in this area according to the principle of supply and demand.

With respect to ventilation, this means that the air exchange rate has to correspond with the actual demand of the inhabitants. The air quality is controlled by means of sensors. Ventilation systems ensure that polluted air from kitchen and bathroom is extracted and, simultaneously, fresh air is led into areas where the nuisance is relatively low - bedroom, living room and hall. Similar optimization strategies can be accomplished for heating, water, lighting, and the like. In addition to the automation of individual partial areas, however, the technical system of a bus structure offers another decisive advantage: On account of the given structure, the different partial areas can be interconnected without any additional effort. This offers the opportunity to consider a house or building as an overall system and, thus, to achieve overall optimization throughout all partial areas. Synergetic effects result from an elaborate coordination of individual processes. Ventilation is a main link between energy conservation and indoor air quality and, thus, will play a major role in buildings installation (s. fig. 1). This paper is intended to explain this type of common utilization of information in the areas heating, ventilation, and safety and security, as well as to present its advantages.



Ventilation as a main subsystem of an integrated interactive home

figure 1

This means that the heating system is provided with information on the number of persons present supplied by the safety and security system. Regulation of the heating system is no longer time-controlled only, but the presence of persons can also be taken into consideration and included in the automation strategy. The basic prerequisite, however, is a building with absolutely separate heating areas.

The same applies to ventilation. If no persons are present, the air exchange rate can be considerably reduced. This would automatically be made by means of a sensor-controlled system, the information that no person is in the house or apartment, however, is especially advantageous with regard to the optimization of the control parameters [2]. In this case, a much faster reaction is possible. In turn, however, a sensor-controlled ventilation system can supply information to a safety and security system. Sensors for indicator gases to regulate the air exchange can easily be complemented to sensor systems which do not only detect CO_2 but also concentrations of other gas components. In the future scenario of a fully automated building absolutely new and useful cross links can result from the interconnection of different partial areas. If the building has a gas port and gas is used in the domestic area, detection of the methane concentration will be extremely appropriate. Even small leaks can be early recognized, the inhabitants alerted, and the gas supply automatically cut off. In coordination with the cut-off, the air exchange rate are increased to the maximum value, and all gas appliances, like heatings, stoves, or flow heaters, turned off. All electrical loads are switched off and the electrical supply is interrupted. If no persons are present in the building, the alarm message is automatically transmitted to an external unit, such as the gas supply company. Different actions to be taken in different areas are coordinated and appropriately harmonized with each other.

In almost the same way a fire detection system can be accomplished. Fire usually starts with smouldering producing CO. If a second element measuring the CO concentration in the air is combined with the sensor, fire detection is possible on the basis of the signals transmitted by this measuring element. In this case, the cross link to the safety and security system is also evident.

Furthermore, sensors monitoring the position of windows and doors can also be appplied in various ways. Their monitoring data are of special significance for the ventilation, as well as for the safety and security system. With respect to multiple application, actuators can also play an important role. If a future system possesses window and door actuators, they can obviously be used by both systems.

Interaction can also be found between heating and ventilation, especially if a reduction of the consumption of heating energy can be accomplished to such an extent that the air in the room can significantly act as a heat transfer medium. In this context, significance means that an important part of the heat transfer is performed via air without increasing the air exchange rate, producing disturbing noise, or causing unpleasant drafts. Under average conditions insulation should be so good that the normal air exchange rate of 0.8 per hour is sufficient to ensure the necessary indoor air quality. It remains to be seen, however, whether this objective can be attained in the future - in any case, it is absolutely worth striving for.

2. IMPROVEMENT POTENTIAL

As already described above, advanced insulation materials and new processing techniques offer a considerable improvement potential in the building area. The potential to be depicted here results from the selected example of an interactive connection between heating, ventilation, and safety and security systems, principally based on the improvement effect caused by new materials. In other words, it represents the 'finishing touch'. If all possibilities of insulation improvement have been exhausted and corresponding tightness of the building has been achieved, the benefit of an intelligent interactive system will reach its maximum.

This benefit can be derived on account of the demand-oriented working principle of the system. It only provides as little system performance in the form of heating energy and fresh-air supply as required under the given circumstances. Thus, it adapts itself perfectly to user behaviour and environmental changes. It offers comprehensive services accomplished with minimum effort independent of the respective circumstances.

This implies saving of energy and, thus, considerable cost reduction. Ventilation regulation ensures constantly high air quality and a healthy room climate. It prevents condensation and removes odour, dust, and pollen. Additionally, uniform heat distribution is sustained.

The integrated safety and security system recognizes hazards, transmits corresponding messages, and eliminates the risk. For the user, such system acts as an attentive butler who assists and relieves him in necessary activities with respect to heat and fresh-air supply and, thus, improves comfort and snugness.

With regard to the environment, two decisive aspects result from the reduction of heating and ventilation efforts. On the one hand the reduced consumption of energy helps to conserve the natural resources, and on the other hand the amount of combustion deposits produced with the supply of heating energy is decreased.

The effect of resource conservation - particularly concerning fossil fuels - can even be intensified, if regenerative energies are integrated and appropriately utilized in the energy supply process. This would result in a reduction of the exhaust of CO and noxious gases, such as SO_2 and NO_x.

3. TECHNICAL REALIZATION

Technical realization of an integrated system is performed in three steps. First, a communications system is required, capable of ensuring the necessary exchange of information independent of the respective application. Such system must be easy to install and adaptable to specific company requirements.

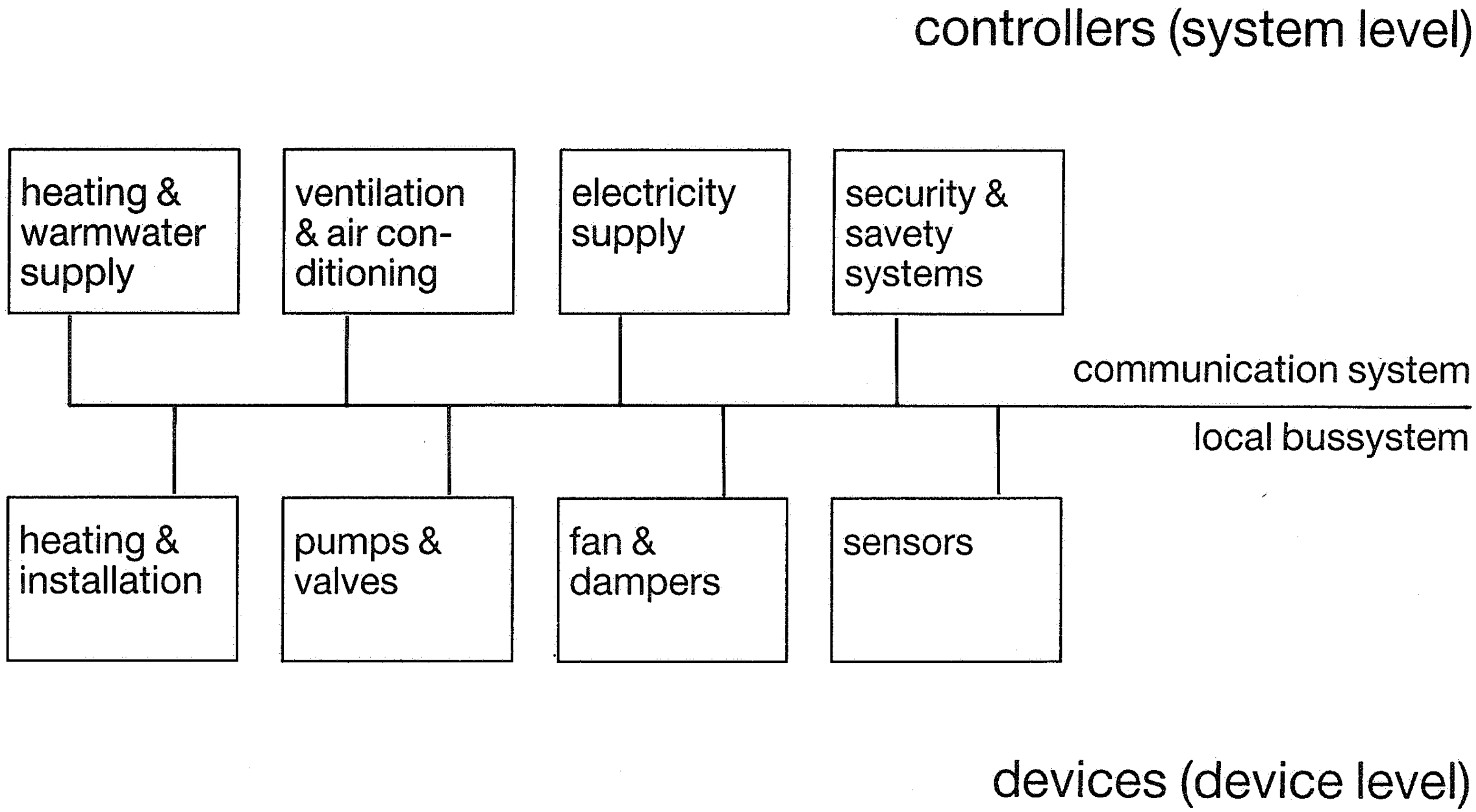
A proposal for standardization of a corresponding system is currently being prepared within the scope of the ESPRIT project 2431 "Home Systems" by 10 of the major electrical manufacturers. The participants comprise ABB, BT, DB/AEG, GEC, LEGRAND, PHILIPS, SIEMENS, THOMSON, THORN, ZELTRON/ZANUSSI. Independent of this project several renowned European companies - under the leadership of SIEMENS - are developing an installation bus system which will be put on the market under the designation European Installation Bus (EIBus). A third system is currently being announced by MERLAN GERAND under the name 'BATIBUS'. In the USA, corresponding activities are performed to introduce a similar system called 'CEBus' (Consumer Electronics Bus). The most advanced development, however, can be found in Japan where first applications of the so-called 'HBS' (Home Bus System) have already been sold. The large variety of these activities gives an indication of the importance attached to this technology and its marketing expectations in the most important industrial regions of the world. It would exceed the scope of the present contribution to discuss the individual specifications, advantages and disadvantages of the different systems. For this reason, only some general remarks shall be made.

Each of these communications systems is based on a bus structure. This means in principle that the entire information exchange is performed via one common information channel so that all information are available to every participant. In some cases, however, this fundamental principle is broken by the application of cluster and sub-bus systems. Certain systems contain different communications media and possess self-organization as well as self-configuration features. Figure 2 depicts the structure and configuration of a general integrated system based on a bus structure.

In addition to a bus system, intelligent components are required in order to ensure information exchange via bus. Concerning our example described above, these components include heating controllers, pumps, valves, fans, vent doors, and various sensors. These sensors mainly perform monitoring of room temperature, air quality, air humidity, and flow velocity. Furthermore, window and door, as well as access control sensors are required. Sensors for air quality monitoring comprise several detectors which determine the concentration of different gas components, such as CO_2, methane, and hydrocarbons in general. CO sensors are important for fire detection while NO_x sensors are required for the elimination of nitrogen oxides produced under smog conditions. In addition to these complex sensors for gas concentration determination, simple temperature and humidity sensors are required. Some of these sensors and detectors can be combined to multisensors - a step which considerably reduces the overall design and integration effort, since evaluation software, as well as a bus system interface, is only required once.

All components, sensors, and actuators are interconnected by means of a bus system requiring little cabling effort. This bvus system includes different communications media, such as twisted pair, coax, radio frequency, diffused infrared, mains communications, and plastic optical fibres. According to the respective application and system environment, appropriate systems can be selected and mutually combined. For retrofit purposes mains signalling is suitable, whereas in new buildings twisted pair seems to be appropriate for heating, ventilation, and safety and security. IR and RF, however, will only be used for portable systems, such as remote control devices for audio and video systems or portable telephones.

Every component of the communications system has to possess its own information interface for reception and transmission. This is also applicable to the simplest components, like switches, valves, pumps, and sensors.



Configuration of an integrated system

figure 2

Logical interconnection of these elements is performed by means of control units equipped with a more complicated software. Such a control unit is capable of combining the different components installed in an area to a small but complete automation system. It contains the entire strategy according to which a coordinated, fully automatic process can be controlled or, in many cases, even regulated.

Each system possesses a user interface. Even if the systems are considered to be fully automatic, the user often wants to interact for information and data retrieval purposes.

The system has a hierarchical structure which also provides redundancies. This increases system safety in case of failure which will never lead to total system failure, since all partial systems are capable of working independently. In case of a failure of the main control unit, the partial systems work on a lower organization level. In case of failure of a partial system, either a redundant system assumes its task or an emergency program is executed. In no case another partial system is impaired. Particularly these considerations concerning system reliability are of special significance in the private sector, since a commercial service infrastructure does not exist. This is at least applicable to the introduction phase.

4. PROSPECTS

It is astonishing to see how the technical capability of processing silicon allows to develop a wide range of new technological systems. Traditional fields, like heating and ventilation, come closer together. And other areas, such as safety and security, entertainment, and communications, which have always been absolutely separate are also combined with the traditional ones. In a continuous evolution, small units grow to modular systems which offer completely new properies. Information availability, free and independent of local circumstances, forms the basis for the accomplishment of these properties. Complex intelligent systems can be accomplished and will replace conventional equipment.

The factor which is decisive for the development of completely new characteristics is the possibility of executing processes in a demand-oriented way due to the increased utilization of information. Another important feature is represented by the anticipation of low costs which are the prerequisite for the required technical basis and the penetration of technology into all social areas. In the future information systems will be an integral part of standard house and apartment equipment. This in turn offers everyone the possibility of contributing decisively to environmental protection. In the first place, the reduction in heating energy consumption will be achieved on account of new building and insulation materials and amount to approx. 60%. All savings going beyond this value, however, will result from intelligent energy consumption supported by advanced information systems. If this process helped to cut the consumption again by half, only 20% of today's heating energy consumption would remain. And eventually, if it were possible to integrate solar energy to a considerable extent into heating energy supply, there would be justified hope that a reduction to even 10% of the present consumption could finally be achieved.

This means that the consumption in the private sector could drastically be reduced. Parallel to such reduction in consumption the atmospheric pollution caused by CO_2 and noxious combustion deposits would be decreased. Additionally, however, another improvement potential can be found in this area, based on continuous optimization of the combustion process by intelligent process control combined with advanced catalytic converters and filtering techniques. If a reduction potential of 90% is assumed for the exhaust of noxious gases, the pollutant emissions in the domestic area will even decrease to 1% compared to the currently applicable values.

Other reduction potentials, though not in the same order, exist in the areas of electrical energy and water supply. Here, damand-oriented systems will also contribute to an increase in the utilization ratio by integrating regenerative resources in the form of solar energy and rainwater. Demand-controlled ventilation only represents a first step in the right direction. In the future, energy and air quality management will find their way to the market in order to meet the complex requirements for the protection of indoor and outdoor environment.

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Discussion
Paper 1

H Hens (Leuven, Belgium)

Be careful with automatising in the private sphere! First: analysis of what people accept, then: automatising the "Autonomous Neutral System" of the building not the private sphere of the user/inhabitant/employee?

R Seyer (Daimler Benz AG, Germany)

Agree.