INTELLIGENT BUILDINGS IN CONTEXT OF ENERGY RATIONALIZATION

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This paper overviews state of the art, the development activities, and futuristic vision on 'smart' and 'intelligent' buildings' construction in context of measures which improve their energy efficiency. The technologies for programming, regulation and automation of energy consumption in buildings, which characterize the current form of 'smart' buildings, together with the implementation of 'intelligent' facades, are already pointing to some significant results which may be accomplished in relation to energy efficiency optimisation of buildings without compromising their greater flexibility and comfort in use. One of the major preconditions for further development of these systems is the integration of design processes which refer to the core of a building and to its installation utilities.

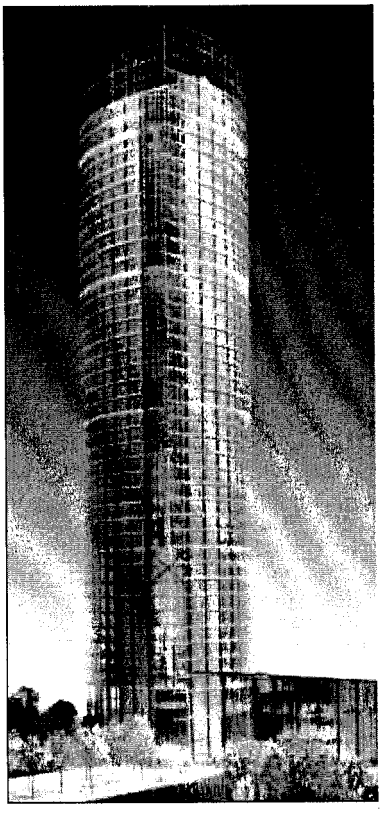
Key words: smart buildings, intelligent facades, green buildings, energy efficiency, energy optimisation.

INTRODUCTION

What do we consider by the term of 'intelligent buildings'? Having that in the anglosaxon literature sources we may also find an expression like 'smart buildings', we can conclude that there is a general confusion stemming from insufficiently precise definitions of these two terms and use of computer jargon in this field. 'Smart' buildings are characterized by complex installations, ranging from air conditioning as a minimum requirement, up to full automation of the entire system of building operation as a maximum condition.

In this paper, we consider 'smart' building to be a construction which is equipped for performance of different management, programming and regulation functions, e.g. programming and regulation of cooling and air conditioning systems; charging for fuel consumption and telephone bills in multi-family buildings; or data collection and analysis for a building and its installations within a long period of time.

'Intelligent building' is defined as the construction with a shell which, besides having a high level of equipment and automation of installations, also consists of materials and components with features that can adjust according to the inside and outside climatic conditions aiming to produce optimal conditions for energy efficient and aesthetically pleasing building use.



Intelligent glass facades

An important factor for functioning of either 'smart' or 'intelligent' buildings is their high-quality maintenance. This also presumes a highly-skilled qualified people for performing the operations of maintenance, otherwise some serious problems that require expensive solutions may well be expected to occur. Regarding all the difficulties that may arise because of the lack of maintenance or organized qualified services in the existing buildings with conventional installations, it is obvious that before any attempt to introduce 'smart' or 'intelligent' edifices to our design and building construction professional practice, it is essential to resolve in the first place some organizational and technical issues of the entire maintenance.

PRESENT WAYS FOR UTILIZING THE INTELLIGENT AND SMART BUILDINGS

Smart buildings

For the time being, the equipment of 'smart buildings' is in the most cases levelled down to systems of management, which serve as the centre for programming and regulation of all conventional building installations, i.e. fire-proof equipment, safety measures, and occasionally, the elevators. Besides all mentioned, a good project for this type of building should also allow for integration with other systems for transferring information in the building, e.g. telecommunications and computer terminals.

A starting point of all measures which aim to achieve increased energy efficiency is the notion that energy should be measured as any other consumer's good. This, however, presumes that something can be managed only if it can be measured and thus quantified and if its consumption and performances can be followed by an adequate monitoring system.

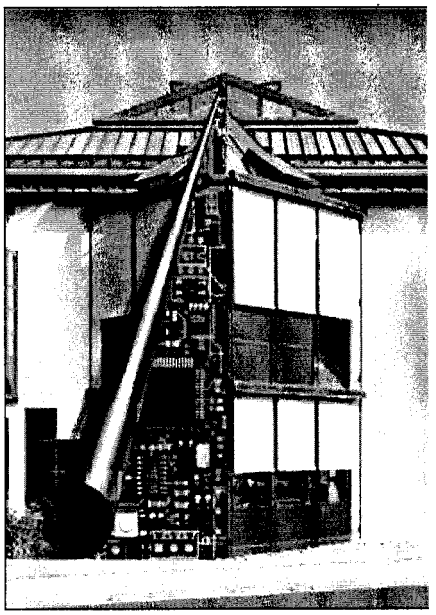
If the first important phase of measuring and managing the energy consumption is represented by setting up of a measuring device, then the next phase will consist of managing the energy by application of programming and regulation, followed by maintenance of optimal humidity and temperature conditions in order to prevent uncontrolled energy consumption.

- *Regulation* can be applied to all energy spenders in buildings (e.g. lighting, heating, ventilation systems, etc.). Regulation of heating is done by thermo-elements which can set up various modes of facade heating regimes, i.e. per surface, per usage, per room, etc. A thermostatic valve is recommended for use in buildings with communal heating system. This also applies to regulation of lighting and ventilation in sport centres.

  In order to become efficient, regulation should be decentralized to the largest possible extent. Regulatory appliances are economically most effective in buildings and in industrial processes. In schools and administrative buildings, the investment in regulation of heating system proves to be mostly efficient since it can be usually redeemed within less than a year.
- *Programming* can be applied to any form of energy consumption in buildings, e.g. lighting, ventilation, engines (pumps, compressors), heating and air-conditioning. It rationally adjusts the power in order to satisfy the energy needs, which is mostly efficient in buildings that are not in constant use. In multi-family residential buildings, the programming and energy measurement should proceed any other action. Better programming requires a simple, relatively centralized automation together with a competent and regular control.

  Programmed heating can bring to savings of 30-50% when applied in schools and offices. Similar kind of savings occur with programmed lighting and ventilation. When programming device is installed on heaters in individual heating systems, it can be expected to achieve 15-25% energy savings in average.
- When process power of a generator is accurately calibrated, then some significant savings may well be accomplished. *Electronic plants with adjustable speed* have considerable potential for energy savings, but also they have a highly positive impact on electric engines regarding their efficiency and longevity. This sort of equipment is applicable on any type of engine.

  Estimated energy savings that can be achieved by incorporation of the above mentioned devices are: 30-50% when used in ventilators or in pumps for boiler supply; 20-25% when used in compressors; 20-35% when used in systems for freezing; and 20% when used for thermal pumps and air-conditioners. It is assumed that under free-market economy conditions, an additional investment in such equipment would pay off in less than 1.5 years.



Intelligent faç ade - Warema Electronic Germany

Intelligent facades

One of the mostly spread types of contemporary intelligent buildings are the multiple glazing facades with louvers and/or constructively or aesthetically shaped shading details. In most number of cases, their 'intelligence' depends on mechanical manipulation of louvers, and only rarely it depends on their control by the automatic systems.

This level of intelligence is in function of a good project, i.e. it provides an integrated participation of all professions that are part of the project team. A right combination of adequate levels for heat and light transmission on the one hand, and level of shade on the other, will notably influence the capacity of installation devices as well as that one of the heating and lighting equipment.

Present versions of this system are using the air canal of the in between space of glazed windows/ glazing systems for removing solar gains in summertime and for reducing the effect of cold breeze in wintertime, or they use reversible louvers that reflect solar gains in summertime and absorb thermal losses in winter.

Wind screens usually incorporate the transparent, thin covers or coatings which absorb the light, are applicable on single or double glazing, and which have such light transmission characteristics that do not make them so much different from their corresponding transparent glazing while offering a wide scope of thermal characteristics depending on the type of screen. Once chosen, such characteristics cannot be altered.

Materials which are potentially best for a controlled use of thermal and illumination features of glazing are thermochromatic, photochromatic, and electrochromatic. Thermochromatic materials are activated by thermal energy; photochromatic by photons, and electrochromatic by the chemical reactions which have been electrically induced.

From the above mentioned 'active types of glazing', the *electrochromatic* one is with best potentials. Depending on voltage level, voltage induction affects the colour or transparency of material (redox materials, electroactive polymers, transition metal oxides, etc.), and when electricity switches off, the film will retain its changed condition until the next voltage exposure.

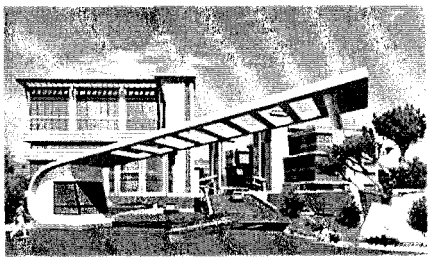
Conditional on changes of the sun radiation, *photochromatic glazing* will change the transmission of light, reducing both illumination and direct transmission of sun radiation, while enhancing the isolation as well. Silver halogens, which are applied to achieve better effects, will influence the glass ability to absorb the heat, which, unless single glazing is applied, can then be re-emitted in the surroundings. Usual application of this type of glazing is for spectacles that use thin glass.

It is not yet possible to predict the time-scale to achieve economical acceptability of electro- and photochromatic glazing production for glass panels in architecture which require different thickness and sizes of these products. Appropriate use of this glazing would necessitate adequate monitoring and measurement of the indoor and outdoor conditions in order to enable transmission characteristics to adjust in a way that would create optimal inner environment with efficient energy use.

Also, there exist *thermochromatic materials* which can be used for glazing to make it opaque as the temperature raises. In energy terms, the lack of this material is manifested by heat absorption in glass which occurs during thermochromatic processes.

When facade elements are in concern, we should also mention the famous *Trombe Walls* for accumulation of solar heat, in which glass plays a significant role in redressing the climatic conditions.

Also, there are some already demonstrated variations on this theme. One of them is *prismatic wall* which operates similarly in a way as the one of rotating marketing panels, where a number of vertical columns with equilateral triangle profile rotates in order to produce three different pictures – compositions. The application of this principle in building construction is based on a fact that exposed sides of columns can vary from absolutely reflective to absolutely absorbing ones, where each stripe contains the material for heat accumulation. We will achieve absolutely homogeneous planes if columns are touching each other. Nevertheless, they can be left semi-opened in order to let some light passing through.



Town Vaastu Shastra, India

The technology of 'intelligent facades' already exists on a micro-level and its further development can be expected. In this respect, the most promising fields are those which are based on technological development of glass and glazing technologies, which allow development of large production capacities and introduction of reasonable prices.

Many of the aforementioned solutions have been criticised as impractical, too expensive or suitable only for special buildings. There is some truth to this but also we have to acknowledge the fact that these principles and

Zoned Heating and Cooling in Florida

many solutions of a kind have been applied in a growing number of buildings. A number of reasons can explain this, e.g. constant development of design process; the need for more efficient buildings; incorporation of new (tested) materials and technologies which appear on the market; and even greater consumer's and investor's demands regarding the building performances.

RESEARCH DEVELOPMENT WORK

In the present phase of development projects and with anticipation of redesigned conditions for their implementation, we have to create conditions for efficient application of new generation of materials and technologies. In the first place, this requires a better coordination between designers and the integration of designing processes. The use of management technologies, regulation and automation are already present in practice, and despite being in many respects in the initial phase, the development of software, the number of companies that gets involved in this field, and money which is to be invested in further development of alternative strategies and technologies, are in constant increase.

Growing numbers of major European research centres, which are specialised in energy efficiency issues are also directing their attention to this field. In this context, most interesting are the works of French "COSTIC" (Comite Scientifique et Tecnique des Industrie Climatique) and CSTB (Centre Scientifique et Technique des Batiment), as well as those of Italian ENEA (Ente per le nuove tecnologie l'energia e l'ambiente).

Apart from an impressive research in the spheres of new and renewable energy sources, rationalisation of energy production processes and environmental protection, which have been conducted in large number of demonstration plants, buildings or settlements, the research field also relates to new systems of residential building automation. These projects aim to improve design of equipment for construction installations, to test compatibility between certain devices and systems while they are in operation, and to enable education of personnel in charge of installation and maintenance of equipment.

Since 'intelligent' and 'smart' houses involve technologies from different sectors of industry (e.g. construction, electrical engineering, electronics, thermal energy, telecommunications, safety, audio-visual devices etc.), researchers and designers have to become increasingly aware of the need to address this area in a

coherent and multidisciplinary way, with application of a system approach.

FUTURISTIC APPROACH TO INTELLIGENT BUILDINGS

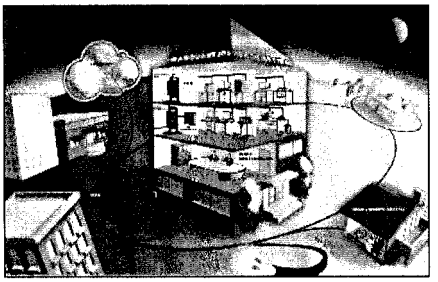
Future architecture will be influenced by a number of factors, e.g. technology; demographic changes; economics; changes in global climate; preservation of resources and environmental protection; and most certainly, by the development and integration of planning and designing processes.

After the periods of 'closed' and 'open' systems, ever intensive use of automation in processes of production of the construction elements will bring to rise of new building technologies which allow 'made-to-measure prefabrication' and even greater freedom of expression through non-linear shapes, domes and 'bubbles'.

New technologies, which will produce such forms by using the multi-layer and sandwich materials, will enable that even those details wouldn't become more expensive than the classical ones. New universal panels will also be applied, and they would be suitable for use at floors, walls or roofs. There is a wide spectrum of materials which will serve that purpose, e.g. wood, steel, aluminium, ferroconcrete, and plastic materials of high performances.

Computer aided design (CAD) advanced to such an extent so it becomes much easier do design on screen than on a sheet of paper. Though producers would provide standardization of a majority of details for their prefabricated products and materials, building details are also to be designed to fit special requirements.

Apart from being of decorative appearance, buildings of the future will also be intelligent. Despite the initial confinement to structuring of intelligent facades, programming and automatic regulation of installations, that process would continue to progress. Some constructions will have installed sensors for detecting voltage, distortion, subsidence, corrosion, and other problems related to major construction elements. Micro-environmental sensors will be installed for following of: temperature and air quality (including the pollution), levels of energy consumption in different parts of buildings, as well as possible infiltration of air or moist through roofs and walls. All these information will be stored in central processor which will control the building's 'health'.



Project From Data Processing Solutions

As the result of possibility to build in non-linear forms, after the 'Art nouveaux' movement and biological architecture, we may expect future renaissance of biomorphism and 'Nouveaux-Art-Nouveaux'. Planning and design will be based on 'sustainable development' principles and protection of heritage.

Solar House, USA

CONCLUSIONS

Broader incorporation of 'smart' and 'intelligent' buildings in practice requires fulfilment of a number of organisational, economic and technological conditions. The level of satisfaction of building users' growing needs will greatly depend on their economic power, hence in lack of free-market criteria, many solutions which require additional investment will need to wait for better times or higher living standards.

In order to demonstrate advantages of such buildings, it is necessary to organise a coordinated development work between producers and users/investors, with aim to produce systems of intelligent buildings according to specifications which represent needs and potentials of users. Further development should also incorporate demonstrating potentials for control and regulating systems in buildings, which can be of particular interest for certain social groups, e.g. senior people associations, people with disability, etc.

In parallel with all the aforementioned measures, it is necessary to continually work on education of designers as well as to pursue with practice of integral type of design, and equally, to implement the actions which would introduce broad public to the concept of intelligent buildings.

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