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From Knowledge to Wisdom

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Smart Buildings for A Sustainable Development

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The use of sustainable technologies for buildings, with the goal of creating an environment for living and working that uses fewer resources and generates less waste, also aims to retrofit existing buildings to be more efficient in terms of energy and water. Many cities are following this way targeting both commercial and municipal buildings. These cities are called smart cities where all life processes and nerve centers of social life are read, in order to radically improve quality of life, opportunity, prosperity, social and economic development, thanks to the use of technology. This paper deals with the study of smart buildings within smart cities, namely the use in an integrated project of computer and telematics tools with automation organized systems and passive bioclimatic strategies in architecture, determining a socio-technical management of intelligent building. The article is the result of a research carried out within the framework of intelligent buildings in the last generation cities, such as those ones with zero emissions that are taking place in the Middle East countries (Dubai, Masdar, Tiajin, and Kochi). The topic deals with the issues of building automation as a form of technological intelligence and the study of those smart technologies integrated into the building envelope that improve its performances, making it more sustainable. The research methodology has provided a bibliographic retrieval on the state of the art and the latest technological trends in the building field, later has followed a theoretical and comparative approach of the examined technologies, which led to the development of reasoning on operation, performance and functional capabilities of a building that is both sustainable and home automation, to arrive at the final concept of sustainable intelligent building, able to combine the artificial intelligence, home automation, and technological devices of the architectural project to enhance the building energy performance. In conclusion, the proposed result is that of an integrated intelligent building in which artificial intelligence will become part of the shell-building in order to achieve high levels of energy efficiency and thus environmental sustainability.

Keywords: smart building, sustainable development, smart city, retrofit, Building Energy Management Systems (BEMS)

Introduction

Smart Buildings Into the Smart City Dimension

The definition of smart city has become particularly popular in recent months. This expression identifies an urban area that, thanks to the widespread use of advanced and pervasive technologies (not only Information and Communication Technologies[1]), is able to address a series of problems and needs in an innovative way.

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[1] Information and communications technology (ICT) is a term often used as an extended synonym for information technology. It stresses the role of unified communications and the integration of telecommunications (telephone lines and wireless signals), computers as well as necessary enterprise software, storage, and audio-visual systems, which enable users to access, store, transmit, and manipulate information.

There are many ways according to which a city can become smart, mobility, economy, government, environment, providing innovative services for monitoring, analysis, planning and management of the flow of the citizens and the media. A smart city is able to collect and disseminate information in an extensive and continuous manner, as regards both the normal social and economic life, and the management of emergency situations. Taking advantage of all the modern technologies for energy saving is to reduce the impact on the environment and on the planet that comes from the presence and activities of thousands of people and products that, in various ways, consume energy and produce waste. By the use of technology, in order to radically improve quality of life, opportunity, prosperity, social and economic development, all life processes and nerve centers of social life in a smart city are simply read (Fuggetta, 2012, pp. 46-47).

The use of sustainable technologies for buildings, with the goal of creating an environment for living and working that uses fewer resources and generates less waste, also aims to retrofit existing buildings to be more efficient in terms of energy and water. These technologies are integrated with other types of services; indeed, to reduce the negative environmental impacts of the construction and management of buildings, some cities are using recovered buildings (buildings retrofit) and certifications that can reduce energy use and water; and smart metering and smart technologies for buildings (smart building technologies) are also used to facilitate the optimization of consumption. Many cities are following the way targeting both commercial and municipal buildings. The public-private partnership between EnVision society, in the city of Charlotte in North Carolina and Cisco society, energy and high technology companies, is fostering a reduction in energy use by 20% in the 60 largest commercial buildings of the city. Paris also aims to retrofit 20% of its municipal buildings and designs 12% reduction in greenhouse gas emissions by 2020. London has launched the Buildings Energy Efficiency Program to retrofit public sector buildings, aiming to a reduction of 440,000 tons of CO_2 per year in 2025 (Berthon, Massat, & Collinson, 2011, p. 18).

These smart strategies are leading to new definitions of intelligence also in the architectural field, by involving more and more frequently, the intelligent building concept. The realization that energy resources are not inexhaustible and the general trend towards a cleaner environment have led to the development of many practices that aim at using energy as optimally as possible. In the building sector this has materialized in the form of Building Energy Management Systems (BEMS). Broadly speaking, BEMS refers to a computerized system that attempts to control all the energy consuming operations in a building. These may include heating and ventilation, lighting, indoor climate, and others. Depending on the level of sophistication these operations may be controlled independently or not. In this way, it is expected that the subtle interrelations between the various parameters are taken into account, resulting in optimum operation (Nikolaou, Kolokotsa, & Stavrakakis, 2002, p. 12). What does smart building mean? What's its origin? This term generally refers to a building with an integrated services platform for the intelligent management of energy facilities, monitoring of consumption, adoption of security systems and video surveillance. However, bringing the smart building to a purely technological matter is certainly simplistic when you consider that it fits into a smart city that develops networks of human relations, sustainable mobility, and energy efficiency improvements.

The Smart Building Automation

Smart buildings can be many things, but simply defined as: Smart buildings use building technology systems to enable services and the operation of a building for the betterment of its occupants and management. The drivers for smart buildings are the positive financial effects of integrated systems, energy conservation, greater systems functionality and the continuing evolution of technology where it is possible to identify different layers: physical layer, data link layer, network layer, and transport layer, interoperable smart building system databases (Sinopoli, 2010, p. 9). Smart building technology generally refers to the integration of four systems: a Building Automation System (BAS), a Telecommunications System (TS), an Office Automation System (OAS), and a Computer Aided Facility Management System (CAFMS). The home automation systems are driving to interesting results related to the increase of efficiency, reduction of waste, accessibility, comfort, safety and making every building active node of an intelligent network, able of sharing data and information with the outside world in an intelligent manner. The most modern concept of building automation considers indeed the building structure and technological systems as a single system-building and works out, through integration, conflicts that often arise from the interaction of each individual process (Beccarello, Andreuzzi, Bruni, & De Feo, 2013, pp. 52-54).

Nowadays, the term smart building is gaining popularity and this concept generated a good deal of market anticipation during the last decade. Though intelligence is an ambiguous term, especially when applied to man-made systems, it is widely accepted that it refers to objects that can react correctly to unforeseen circumstances by choosing amongst a set of possible actions and furthermore can learn from the associated response. The concepts of self-correction or fault tolerance are considered as essential elements of artificial intelligence. It is also widely accepted that the means to achieve intelligence consist of tools that resemble human intelligence methods, such as neural networks and logic (Nikolaou et al., 2002, p. 11). The smart building concept has its roots also in the idea of BEMS originated in the USA in the early 1970s. They initially consisted of dumb outstations, which collected data and fed them to a central station. The central station was the only part of the system with some intelligence. BEMS from the early 1980s are now considered cumbersome compared with today’s systems. The next development was the introduction of the intelligent outstation, which resulted from the development of the personal computer low-cost. The typical centralized commercial BEMS consist of the central station and a number of outstations. The outstation accepts inputs from sensors monitoring the values of variables, such as flow and return temperatures of a heating system. The central station is where most of the long-term data storage takes place.

Figure 1. Personal computer hosted centralized architecture currently available in the market.

Origin of Smart Building Automation

There was a general expansion in the construction industry after World War II. A desire to improve comfort into larger buildings is characterized by more complex mechanical systems. The impact of this was the development of better heating and cooling control systems. The large size of buildings was one of the major forces behind the concept of centralization. In the 1950s, the introduction of the pneumatic sensor-transmitter permitting local indication and remote signal and the receiver-controller with optional remote adjustment were the major reasons that led to pneumatic centralization. The number of local control panels was thus highly reduced to a more-or-less single centre which was located in a control room. Another trend, miniaturization, resulted in the reduction of the physical size of instruments. The use of electronic sensors and analogue control loops by the end of this decade resulted in a hardwired centralized control centre (Figure 1). In the 1960s, the introduction of control companies for commercial buildings helped the development of new technologies.

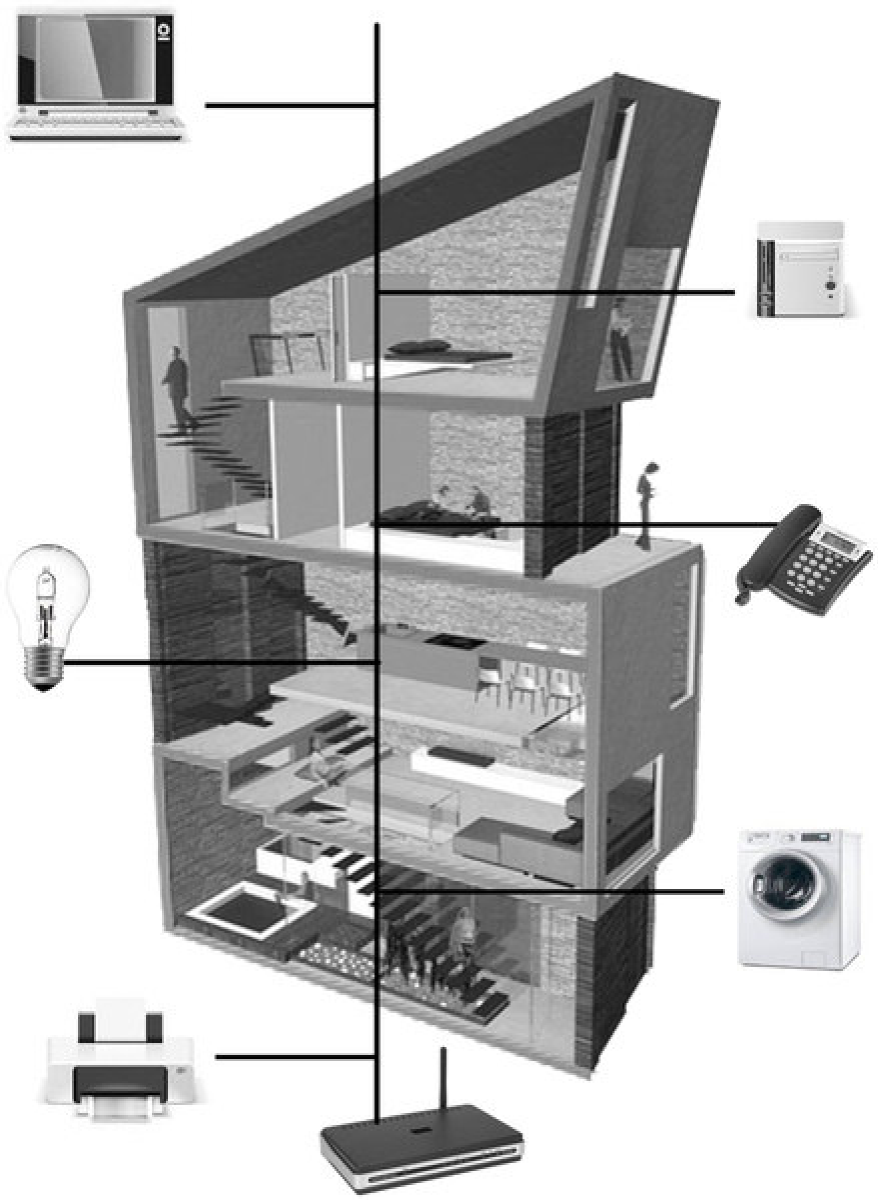
Electromechanical multiplexing systems were introduced, resulting in reduction in installation costs and maintenance. Wires were reduced from hundreds to a few dozen wires per multiplexer. The control centre panel was transformed into a control center console. Commercial digital indication and logging systems were available on the control centre console to permit the automatic recording of selected parameters during unusual conditions and to provide information of those selected parameters. Automatic control of systems, like air-handling units (*AHUs*)[2], became possible. Temperature, flow, pressure, and other equipment parameters were monitored on the console. Intercom systems and phones were also part of the console. The first computerized building automation control centre was marketed late in the 1960s and data communication was done by means of coaxial cables or twisted pairs.

A new term, energy management system (EMS), was derived and became a standard in the control manufacturers' sales brochures. New application software packages were incorporated into their basic automation systems. Some packages such as duty cycle demand control, optimum start/stop, optimum temperature, day/night control, and enthalpy control were introduced. Additionally, fire and security systems were emerging from building automation systems. The building owner could directly be in contact with the systems by keeping track of energy usage and cost (Figure 2).

By the mid-1970s, the cost of hardware began to decrease. Systems became user-friendly and it was possible to program and generate a new data base on the same system. In the 1980s, the introduction of personal computers revolutionized the control industry. The lower cost of chips was the principal cause of the development of new technology in building automation and energy management. The resultant rapid change motivated manufacturers to engage in research and development rather than investing in their existing hardware and software. The production of individual microprocessor based distributed direct digital control was accepted by the users because of the large use of personal computers in the engineering work areas and at universities (Nikolaou et al., 2002, p. 13). The development of automatic control systems has resulted in intelligent buildings with a wide range of building automation facilities.

The energy efficiency of buildings combines many technologies: passive heating and cooling through the building envelope; efficient daylight penetration using suitable shading devices; efficient appliances that reduce the electricity consumption and cost; increased thermal insulation; high efficiency windows (low-E coatings, etc.); natural ventilation for indoor air quality and passive cooling (cross ventilation, stack effect ventilation, etc.); improvements in building services Heating Ventilation and Air Conditioning (HVAC) technologies and Building Energy Management and Control (Nikolaou et al., 2002, p. 14).

[2] An air handler, or air handling unit (often abbreviated to AHUs), is a device used to regulate and circulate air as part of a heating, ventilating, and air-conditioning (HVAC) system. An air handler is usually a large metal box containing blower, heating or cooling elements, filter racks or chambers, sound attenuators, and dampers.



Ethernet

Figure 2. Home area network to connect digital devices.

Components of Smart Building Automation

In smart building design, the building facade constitutes the boundary, as opposed to the barrier, between the indoor and external environments. The building skin is therefore a moderator of flows, adjusting gains and losses to and from the interior either inherently, through static elements such as building mass, or cohesively through automatic response or control. Some of the elements which have to be regulated by the building envelope are water, humidity, air, sound, light, view, heat, fire, pollution, safety, and security. When implementing any specific control strategy, conflicts which arise between these parameters must also be taken into account. External shading devices can be adjusted by intelligent control systems, indeed such shading devices can also have incorporated photovoltaic panels for integration of renewable energy sources. Solar gains may also be controlled by advanced glazing materials which can respond to sunlight or changes in temperature or the properties of which can be controlled by application of a low voltage.

Double Skinned Buildings

In a similar manner, stack ventilation, supply air preheating, and background heating can form an integral part of the design process of double skinned buildings. In these systems openings and shading can be adjusted in response to environmental parameters, taking into account temperature, humidity, and solar radiation. Since smart building design seeks to maximize the benefit to occupants through combined regulation of the above parameters, control algorithms have to be utilized to reach optimum performance. The fully integrated building, in which all of the electronic systems serving the user and the building itself are combined, has yet to become a practical reality. One of the main reasons for this is the valid concern that non-critical systems, such as user IT, and critical systems, such as fire and safety, should not be integrated in one system. Current research in the field of software developments focuses on the application of artificial intelligence techniques for robust, adaptive control of buildings and their energy consuming systems using fuzzy logic, neural networks, and generic algorithms.

New Technologies for Smart Buildings

Research and development of new control strategies using fuzzy logic techniques for building services concern three basic aspects of building control: automatic control of individual zones through thermostatic control (fan coil, zone damper, etc.); automatic control of boiler plant and central HVAC (Heating Ventilation Air Conditioning) systems (water temperature, coil temperature, fresh air mixing ration, etc.); global control of thermal comfort, visual comfort (Daylight Glare Index) and indoor air quality (CO_2), including integration of building component control and utilization of renewable energy sources (passive solar, natural ventilation, etc.).

In recent years, many applied research projects have been developed and completed concerning hardware applications. These projects demonstrate the current developments with regards to the future technologies which will be included in the buildings of tomorrow:

- Energy Barometer is a project that has been developed to measure energy use in relation to internal and external climate in many different types of single-family houses;
- Radio-Teleswitch is a system that has been developed for remote control of storage heating and hot water systems, using radio frequency 198 kHz;
- Weathercall is used for automatic storage heater charge control and domestic hot water storage;
- Celect is an extension of Radio-Teleswitch and Weathercall systems that gives more sophisticated local control of heating systems;
- Cenesys is a project which the aim was to develop optimum control strategies for HVAC systems, based on multictriteria analysis, by the use of fuzzy controllers and to develop and compare smart tuning techniques for these controllers;
- Scrats are in Smart Controls and Thermal Comfort project. A wide-ranging thermal comfort survey was carried out in different climatic regions of Europe and resulted to the development of algorithms for use in control systems for air conditioned and natural ventilated buildings in order to reduce energy use;
- Builtech has been developed to test and document an integrated building EMS combining intelligent decision making systems, and smart card techniques and based on recent local operating network, technology

which is suitable for existing buildings equipped with conventional energy facilities, as well as for new buildings without construction modifications.

HVAC system controls are the information link between varying energy demands of a building's primary and secondary systems and the approximately uniform demands for indoor environmental conditions. Without a properly functioning control system, the most expensive, most thoroughly designed HVAC system will be a failure. It simply will not control indoor conditions to provide comfort. The HVAC control system should be designed in order to be able to sustain a comfortable building interior environment; to maintain acceptable indoor air quality; to be as simple and inexpensive as possible and yet to meet HVAC system operation criteria reliably for the system lifetime; to result in efficient HVAC system operation under all conditions. The HVAC system not only makes the building comfortable, healthful, and livable for its occupants, it also manages a substantial portion of energy usage and related costs for the building. In maintaining the building's air quality, the HVAC system must respond to a variety of conditions inside and outside the building (including weather, time of day, different types of spaces within a building and building occupancy), while simultaneously optimizing its operations and related energy usage.

The HVAC system is also critical in controlling smoke in the event of a fire. A major step to maximize HVAC efficiency in a building is reducing heating and cooling loads. Reducing heating loads is as simple as installing more efficient lighting and electronics. Incandescent lighting generates large amounts of heat while lighting an area. Modern energy-efficient fluorescent lighting provides the same and often better light quality with much lower heat output. Computer systems and servers also generate significant heat, and can be upgraded to more energy-efficient versions. Dark color on the outside of a building increases the absorption of solar heat and the thermal load of an HVAC system. Reducing cooling loads can be accomplished by installing better insulation and more efficient windows and sealing air leaks. Interior spaces in a building often need cooling during times when the outdoor air temperature and humidity are sufficiently low to provide cooling without running refrigeration equipment. The correct sizing of an HVAC system's cooling capacity should not be based purely on the size of a building.

The envelope load (windows, walls, and roof), the internal thermal loads (lights, people, and equipment), and the ventilation load must also be considered (Figure 3). The concept of displacement ventilation can drastically improve HVAC system efficiency and ventilation quality. Traditional ventilation mixes a turbulent stream of fresh air with waste air that has been exhaled by occupants of a space, creating a constant mix of medium-quality air. Displacement ventilation uses a slow-moving stream of fresh air from the floor to displace the waste air, which is forced to the ceiling and then out of the room through exhaust panels. This creates two levels of air in a room, with cool fresh air in the occupied lower part of the room, and warm waste air in the unoccupied upper part of the room. This also creates natural convection, because as the cool air rises it cools the occupants and then the heat taken from them is expelled from the room. Displacement ventilation can eliminate the need for large HVAC equipment, not only reducing energy costs but initial and maintenance costs as well (Sinopoli, 2010, p. 43).

Another significant development within the technology of intelligent microprocessor based controls is the use of intelligent lighting controls. These controls provide greater flexibility, leading to better management of light. They make it possible to create an aesthetically pleasing environment, while at the same time saving energy. The concept behind these controls is to operate lighting automatically according to the function of an area, the time of day, ambient light levels, or occupancy. An important aspect is the programmability, that is, the ability to remember lighting levels as a series of settings.

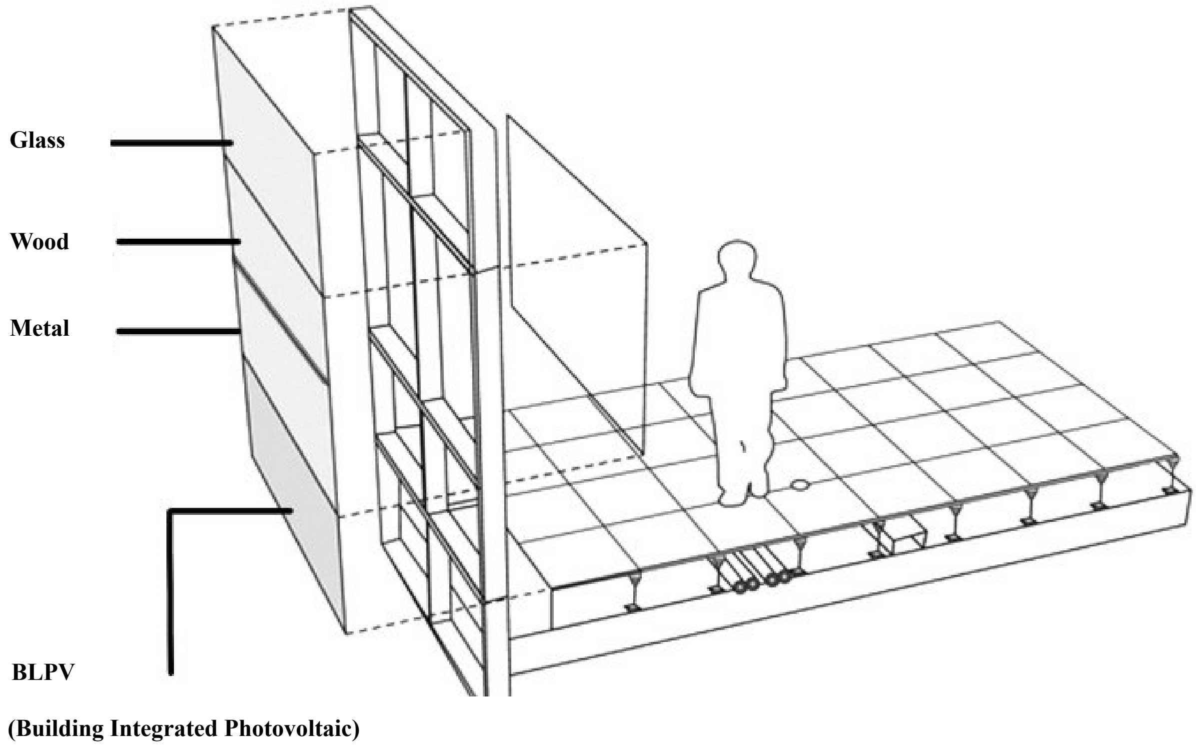


Figure 3. Example of a pubblic building automation system.

Lighting System for Smart Buildings

These settings, also known as scenes, can be recalled automatically by the dimmer system or by the central building control system. Lighting controls can stand alone, either be room-dependant types, or larger networked systems, where the dimmer units are fitted in an electrical cupboard and operated by a network of external devices like sensors and control panels. The networked systems have the advantage of allowing control of different rooms or areas from many points. In a domestic setting, this could be a wall mounted switch panel near the main entrance that acts as a master to several rooms.

The information from the lighting system can also be used for determining energy consumption or for mimicking occupancy patterns while the house is unoccupied. Standalone dimmers can be interfaced too, via infra-red remote control though this only provides for one way operation without the ability of determining if a request has taken place. Intelligent lighting controls have many advantages over manual ones, including convenience, creating ambience, increased design flexibility, energy savings, reduced lamp replacement costs, and security. Facility lighting is needed to provide visibility for building occupants, aesthetic atmosphere for spaces or rooms and for life safety. It is estimated that lighting accounts for 30% to 40% of electricity usage and costs in a typical building.

The need for lighting in a building varies by the type of building, spaces within the building, time of day, and occupancy of the building. Consequently, the control strategies and functions of a lighting control system reflect these variables and primarily involve the following: scheduling—a control system may have a predetermined schedule when lights are turned on and turned off; occupancy sensors—for spaces in a building where occupancy is difficult to predict, lights may be turned on and off based on a lighting control system device sensing occupancy; a daylight—to reduce the need and cost of lighting spaces a control system utilizes natural light as much as possible. This is sometimes called daylight harvesting or daylighting; window coatings—spectrally selective window coatings, designed for hot climates with large amounts of solar radiation, working by selectively filtering out frequencies of light that produce heat while minimizing the loss of visible light transmission. The lighting control system distributes power to the available lighting units in a typical fashion, but inserts digital control and intelligence in many, if not all, of the devices controlling the lighting such as the circuit breaker panel, wall switches, photo cells, occupancy sensors, backup power, and lighting fixtures. The control system significantly increases the functionality and flexibility of the lighting system by providing digital control and intelligence to the end devices, for example, a reconfiguration of lighting zones is accomplished through software rather than the physical cabling of the lighting zones. In addition, intelligent end devices allow more focused application of lighting control needs and strategies to specific spaces in the building. Photoelectric controls are designed to strategically use daylight to reduce the need for artificial lighting, a process called daylight harvesting. They may be located in perimeter offices, atriums, hallways or in areas with skylights. Ambient light sensors measure natural and ambient light then based on the amount of natural light, adjust the lighting to maintain a constant light level. In some spaces manual or automatic blinds, or other means of reducing the direct solar exposure glare, excessive light levels, and heat gain, can be used to supplement photoelectric controls. Daylight harvesting provides little benefit without an integrated electric lighting system due to the increased thermal loads from the sun. The electric lighting and thermal loads must be reduced while simultaneously increasing daylight to an area.

EMS of Smart Buildings

Another element of the smart building is the Electricity Usage Metering and Submetering. A smart meter identifies consumption in more detail than a conventional meter, sends data back to the local utility for monitoring and billing purposes, and may provide information and data to the consumer directly. An electric meter is a device that measures the amount of electricity consumed at a particular location. In order to accurately bill a customer, a meter is needed to record consumption. When billing a customer, utilities record the electricity usage as well as the time when the electricity was used, since prices may vary throughout the day. Meters provide information allowing customers to control electricity consumption and demand, determine typical consumption, evaluate opportunities for improving energy efficiency, and confirm savings from building and/or building systems improvements. Newer smart meters allow utility customers to monitor demand, power outages, and power quality in real time. Other components are access control system, video surveillance systems, fire alarm and mass notification systems, and data networks.

But an important smart component is the EMS that generates information on energy usage and related costs for the purpose of reducing costs while still maintaining a comfortable and safe environment for building occupants. Electrical utilities base their charges on several factors, but the most important are power consumption and demand. Smart structures and material technologies are a tool for sharing the knowledge of how various building materials can significantly increase production and profit using advanced communication, collaboration and management technologies (Sherif & Sabry, 2013, pp. 1512-1521). With the last evolution, the concept has been driving toward composite materials where two or more distinct material phases are being combined together to provide a better combination of properties.

Currently, the next evolutionary step is being contemplated with the concept of smart materials. The smart materials have been divided into two groups: passive smart materials which can only perceive and feel the stimuli of the environment as well as of the own inner and are being acted as sensors; active smart materials which have the properties of passive ones and additionally react to stimuli and have also the actuator. At a more sophisticated level, such smart materials become intelligent when they have the ability to respond intelligently and autonomously to dynamically-changing environmental conditions, also smart components for the building can be identified, such as smart windows and technologies that have advanced significantly. Window technologies made up of suspended particle devices, capable of functioning like a light valve in controlling the amount of light able to pass through a window, are now being produced. Suspended particle devices window technology is both practical and affordable and, through aftermarket vendors, can be retrofitted to existing buildings (Figure 4).

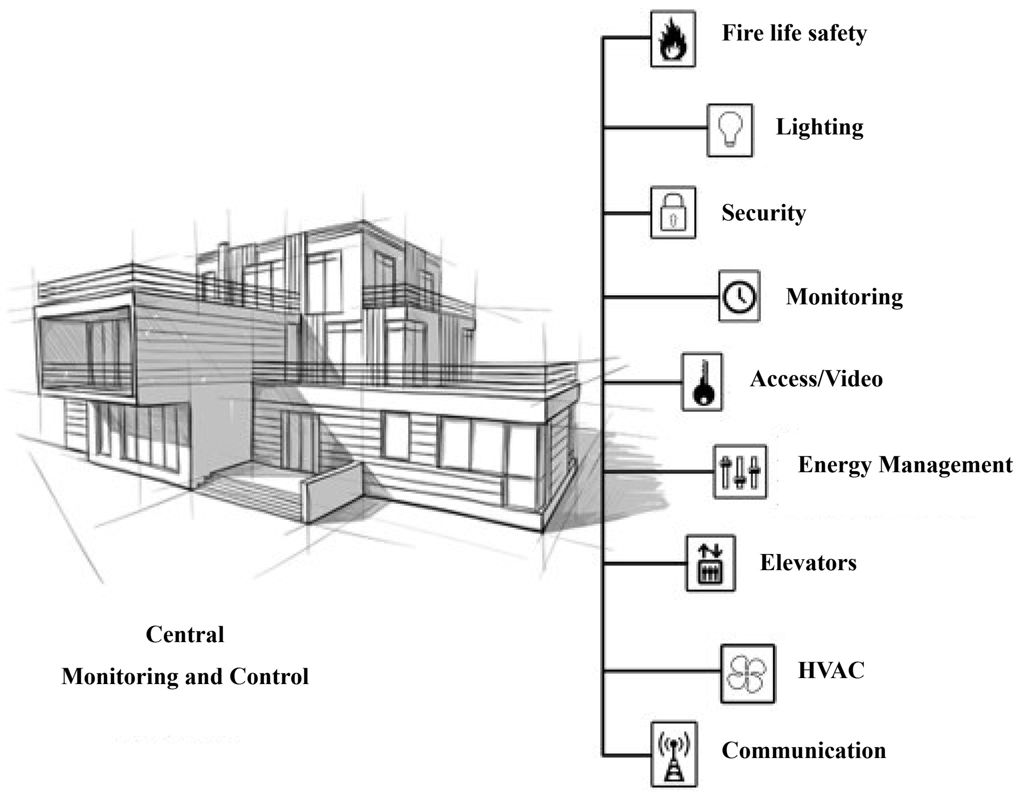


Figure 4. Vacuum Insulation Panel (VIP) modules with innovative design.

Smart shade employs the thermodynamics of zinc and steel to control the amount of sunlight passing into a building's interior using elastic shape memory alloy wires to control the level of carbon dioxide in a room. Expansion and contraction of these sandwiched materials in response to temperature cause the blinds to curl up in winter (allowing more sunlight in) and curve down in summer (allowing less).

Roofing is to impart protection and covering to the buildings using the renewable energy resources like vegetated green roofs and photovoltaic modules. Photovoltaic modules (which convert sunlight into electricity) are integrated into roofing materials and are mounted on rooftop racks. Once installed, photovoltaic roofing produces free electricity from sunlight that can power certain home functions or supply most.

Ceilings, with anti-bacterial treatment called the anti-microbial ceilings, include an intercept coating that destabilizes the cellular membrane of certain microorganisms preventing them from multiplying and surviving. The coating inhibits the growth of odor and stain-causing bacteria on the treated surface of the ceiling tile.

Sustainable Intelligent Building

Europe contains some 160 million buildings, as estimated by experts of the European Construction Technology Platform. Only some 65,000 are presently estimated to be so called passivhaus buildings, which represents a mere 0.04% of the total stock (Bax, Cruxent, & Komornicki, 2004, p. 5). When assessing the key challenges of cities to become smart cities, the area of energy efficiency in buildings should be addressed taking into account the fundamental differences between new buildings (the ones which are to be built now and in the future) and the existing building stock (all buildings that are found in cities today). Five solutions could be combined from the chemical industry bringing significant energy savings: reflective indoor coatings; high reflectance and durable outdoor coating; Phase Change Materials (PCM); new insulation foams; other insulation modules.

Following the areas of transport and power generation, building technology is the largest consumer of energy. Heating, cooling, and lighting in residential and office buildings make up approximately 40% of the energy consumed in the industrial nations. On the European level, this fact has been met with the publication of a directive relating to the energy performance of buildings (Retrieved from http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32002L0091; http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:153:0013:0035:EN:PDF).

Energy efficiency of a system is the ability to exploit the energy supplied to it to satisfy the required needs. The lower the fuel consumption is related to the fulfillment of a specific requirement, the greater the energy efficiency is.

The term energy efficiency in buildings involves all those actions of programming, planning, design, and construction that allow you to achieve the primary goal of saving energy (efficiency is to be understood with reference to the energy system as a whole system building/facilities as the ability to ensure service delivering, such as heating, through the use of the least amount of energy). The nearly zero energy building is a high-energy performance building, in which the energy requirements very low or almost zero should be covered, in a very significant measure, by energy from renewable sources. It is a new concept of intelligent building which could involve sustainable, in this smart strategy, the passivhaus concept, developed with the goal of making energy-efficient buildings and reasonable costs for the northern European climate. Passive building means a building that with appropriate strategies you try to take advantage by the microclimate characteristics (sun, wind, land morphology, etc.) of the area where the building is situated, to obtain a reduction in hot or cold inside otherwise achievable by means of air conditioning systems.

Particular constructive standard is based on the integration of technologies and building materials that ensure high quality of life and a very sensitive reduction of energy consumption. These buildings, characterized by a highly insulated envelope and free of thermal bridges, with large southern windows, with a controlled ventilation system with heat recovery, are able to take advantage of passive solar gains and internal heat sources (people, equipment, machinery, artificial lighting), without a conventional heating system for winter heating.

Basically the house maintains the ideal temperature, hence the term passivhaus. The energy required to equalize the heat balance of the building is typically provided with non-conventional systems (e.g. solar panels or heat pump to heat the air of the controlled ventilation energy recovery system). The main requirement that the intelligent passive building incorporates is the issue of an energy certificate detailing the energy consumption of the building as well as analysis of the potential savings.

The expression passive cooling refers to all those processes of heat dispersion that occur naturally without the adoption of mechanical means or energy consumption. The generalized use of air conditioning systems involves considerable consumption of energy and contributes significantly to increase air pollution. Using natural techniques of cooling can be, in most cases, sufficient to our latitudes to restore the conditions of comfort inside buildings, limiting energy consumption and pollutant emissions.

Other passive systems include the construction of: chimney effect and solar chimney, tanks of fresh air, wind towers, and skylights. The passivhaus model corresponds to a building that allows you to achieve thermal comfort without the need for conventional heating systems, aiming to reduce energy losses, improve free heat gains. To this end, the following bioclimatic principles should be observed: a compact form of the building, shell insulation (including frames) with elimination of thermal bridges, large solar gain through insulating glass positioned on the southern parts of building, air changes through controlled mechanical ventilation with heat recovery, production of hot water by solar collectors or heat pumps, electrical devices with low consumption. In addition, the recent trend observed in the design and production of components of intelligent building, consisting of dynamic layers, shows the need to identify the technological functional quality and performance parameters that drive the choices of the actors of the innovation process and push them to develop solutions and proposals to transform the building envelope from static element to dynamic element, able of interacting, via interoperability of its components, with the input of the internal and external environment, which refers to the building placed, as a border and boundary system. The field of smart envelopes is a response to the need to develop a facade system able of ensuring flexible energy performances and adapted to the Mediterranean climatic conditions, through transparent double-skin facade systems trying to develop a new component of vertical closure characterized by the possibility to change its configuration during the year at the passing of the seasons (Sala & Romano, 2011, pp. 158-162).

The dynamic facade system is, therefore, an innovative solution for its aesthetic and technological features, able to respond effectively to market demands of the building envelope components. In the 1960s, another strategy takes place that today it could include within the concept of intelligent sustainable design building: the bioclimatic approach. Bioclimatic architecture is a complex design solution that ensures the maintenance of conditions of well-being, in a building, minimizing the use of traditional systems that require energy from exhaustible sources. The building must be able to control the environmental conditions in virtue of its morphological distributive dimensional and thermo-physical characteristics. If a building uses renewable energy sources for its air conditioning it should be selective and able to dynamically manage the energy flows in and out (gains and losses), so in the design phase must be consider the variables related to: characteristics of the site, building shape, envelope configuration, and indoor layout. The passivhaus, the bioclimatic approach and smart envelopes can then be classified among the smart approaches that architecture is undertaking for the realization of intelligent building in which the intelligent network of sensors interacts with the technology itself of the building (Figure 5).

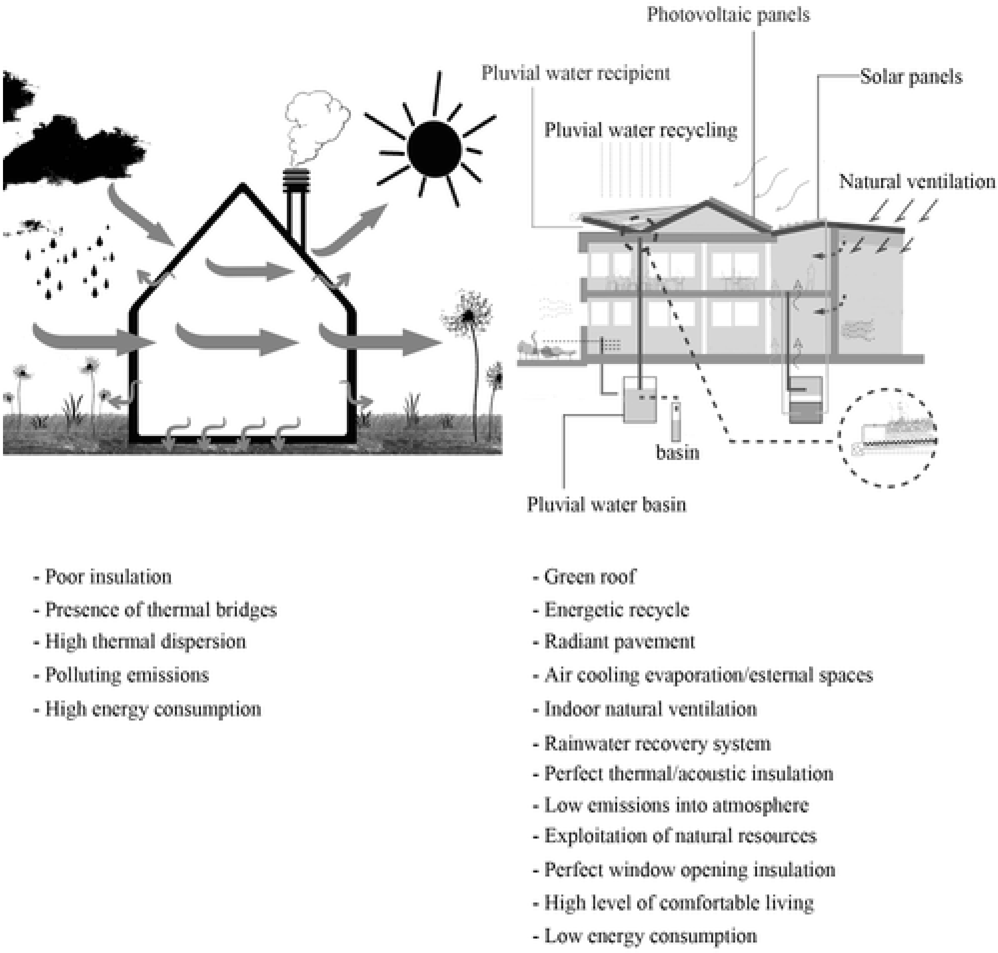


Figure 5. Example of bioclimatic approach and smart envelopes.

Conclusions

The study of new smart cities, about the targets for the reduction of CO_2 emissions by 2020 and the major European examples, presented in the first part of the article, has allowed identifying the best international practices of smart strategies that have involved the construction of smart buildings as main catalysts of new energy. Afterwards, the research has covered an analysis of intelligent buildings historical evolution, starting from the 70s, to understand challenges and differences compared to the new concept of smart building. A study about materials and technological units that are part of the new architectural organism has been also involved according to the European Directives aimed at buildings energy saving. In the last part of the article, some characterizing parameters of the so-called green buildings or passivhaus system have been taken into account as architectural strategies aimed at reducing of consumption and at the fulfillment of the green architecture principles on cooling and interior comfort, as further form of smart buildings and, such as defined intelligent sustainable buildings have been classified.

A sustainable intelligent building provides as common factor all the elements that determine the high energy efficiency and complex automation, aiming to achieve the objectives set by the European Union within 2020. Strong commitment to maintain is to derive 17% of production from renewable energy sources, by 2020, 20% of primary energy. The term smart indicates the ability to manage, in a simplified manner; the technology inside the building, which to be smart has to integrate systems and automation, to be programmable and customizable and must be able to grow following the technological evolution. Furthermore, today a building must be interconnected: There must be a chance to oversee the facilities in a centralized manner, both locally and remotely (Mangalaviti, 2012, pp. 60-65).

Climate change and growing shortages of resources are the big challenges of current time. In addition, many countries around the world are dependent on imported energy, in the EU, for example, 50% of energy consumed today is imported, a figure expected to reach 70% by 2030. Recent studies have shown that leadership in energy and environmental design (LEED) certification has a positive financial effect on the value of a building. Thus, if a building owner is upgrading systems and wants added financial value, incorporating LEED certification as a part of the strategy makes sense. A critical part of LEED certification for existing buildings (which focuses on operations and maintenance) is system upgrades. Much of what is often proposed as a strategy for existing buildings can satisfy some of the LEED criteria. LEED certification for existing buildings also requires addressing issues rather than system upgrades such as recycling, exterior maintenance programs, and cleaning or maintenance issues. Integrating a building's technology systems and constructing a sustainable or green building have much in common. Green buildings are about resource efficiency, life-cycle effects, and building performance.

Smart buildings, whose core is integrated building technology systems, are about construction and operational efficiencies and enhanced management and occupant functions. Part of what a smart building will deliver is energy control and energy cost savings beyond that of traditional systems installation due to the tighter control system integration. Smart and green buildings deliver the financial and conservation benefits of energy management. Smart buildings are a part of green buildings and greatly support and affect green building certification. Studying smart buildings, namely the use in an integrated project of computer and telematics tools with automation organized systems and passive bioclimatic strategies in architecture, determines a socio-technical management of intelligent building, where the technological and the human factor cooperate in the definition of sustainable intelligent building and smart home automation (Tranconi, 1990, pp. 20-22).

Talking about intelligent building means proposing new solutions of active envelope, able to reduce the environmental impact of the systems related to the construction field; architectural integration of a system of building advanced screen envelope able of ensuring good lighting, thermal regulation, energy production, in addition to the basic functions of protection against water and temperature control; the development of a modular system that allows variables architectural aesthetic solutions in relation to the needs of the designer and ensuring a geometrical continuity of the facade; the possibility of integrating technologies for the production of renewable energy and the ability to guarantee variables thermo-hygrometric performance in relation to the outside climate.

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