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The New Integrated Management of Efficient Buildings: An Intelligent Method Approach and AI

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Abstract: Building process innovation highlights building systems and products that denounce both an incremental and radical development, indicating the technological sector as the driver for energy efficiency. The prototypes of this innovation stand out both in the tertiary and residential sector and are aimed at sustainable development with the use of renewable resources, intelligent technologies, with a view to contextualizing and environmental energy requalification. The objectives are those of a new integrated building management, intended as an increase in energy efficiency and an efficient digitalized connection with users and smart grids, through control platforms, IoT (internet of things), security throughout the building's life cycle and use of AI (artificial intelligence) devices and materials. The approach is a new methodology, with the application of BMS (building management system) and BEMS (building energy management system) systems integrated with other systems, with an interface of protocols open to different manufacturers and multiple functions that invest both the technological and environmental system of the building, with advantages in electrical energy management and thermoelectric like intelligent HVAC systems, with intelligent monitoring and user comfort. Both the new Artificial Intelligence and Machine Learning platforms contribute to a predictive use of energy efficiency with plant optimization. Therefore efficiency and energy saving strategies with intelligent integrated management and medium-long term maintenance programs. The challenge is a new intelligent method approach with the use of artificial intelligence and the development of new technologies in sustainable buildings.

Key words: Technology, system integration, energy, sustainability, artificial intelligence.

1. Introduction

Process innovation is seen from both a radical point of view, as a production system capable of reducing costs, increasing productivity and efficiency, and incremental, improving the production process, especially in construction, in the adoption of intelligent materials and adaptive with new energy technologies. In particular, innovation aims at the industrialization and digitization of a new construction process, through an integrated technological design, for efficient envelopes in various technological solutions, process instruments and methodologies.

These technologies constitute *brand awareness*, a measure of the degree of knowledge and notoriety of a brand, for producers of new markets by networking with construction companies and whose investment choices, characterized above all for taxation and expenditure subsidies for investment goods, they represent the economic recovery of some European countries with global echo. In fact, the new market opportunities present segmentation in the tertiary sector with a greater tendency for the redevelopment of buildings and for new realizations, providing new job opportunities and highlighting skills with a wide diffusion of efficient types of envelopes in the construction sector. So objectives of an environmental and contextual control in contrasting climate change, and pressure of energy supply, through new sustainable and integrated, energy-saving architectures, with conscious use of renewable resources and redevelopment of buildings, improving productivity, especially in the sector building, and aiming for new

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energy models that use fewer resources and above all provide comfort, thermo-hygrometric well-being, visual, acoustic well-being and usability in indoor environments.

Therefore design methodologies are integrated with the interoperability of the team of designers, energy systems and new technologies, towards the intelligence and high performance of energy self-sufficient buildings, in line with European directives Dir. 2018/844/EU, which updates the Dir. 2010/31/UE [1] and Dir. 2012/27/UE and with the use of BIM, drones and AI input. Innovation in efficient envelopes solutions, through IT (Information Technology), with methodologies of intelligent systems, such as BSC (Building Skin Control) with remote control for the automatic management of glass facades with aluminum windows, Mecatronic TipTronic SimplySmart, aimed above all at energy efficiency and greater comfort. There are intelligent upgradeable systems such as Schüco BSC [2], which favors the networking of devices, being able to interconnect through the central controller, up to 30 windows, both with each other and with the building management systems, with a KNX or BACnet gateway, and commissioning with software. It can also be connected to the internal cloud, facilitates remote access to users who interface via app, with voice control, for communication, control and monitoring of the enclosure. This function can also be performed through the Amazon Alexa voice command, etc. In addition, integrated BMS (building management system) systems are adopted for energy management, monitoring and comfort with protocols interface open to multiple manufacturers with the use of IoT (internet of things) technologies for high energy savings. The approach in this new integration method is supported by new experiments with emerging AI (artificial intelligence) technologies and interaction with robotic ML (machine learning), etc. [3] which identify, through algorithms (intelligent agents) and sensors, the non-invasive operating potential of the systems for energy management, HVAC (heating, ventilating, and air conditioning), of the control system, of safety, of prefabrication of building construction and more. Therefore an integrated vision of a new method of creating more connected and smart efficient buildings is with emerging technologies and advanced systems, also through an SRI (smart readiness indicator) indicator, which interfaces with the external environment through smart networks, with users, services with automation and monitoring. So greater time savings and reduced investment costs and high quality and productivity in sustainable energy-efficient architectures are based on modularization and prefabrication and FM (facility management), including the recent Rogers Stirk Harbor + Partners Center Building, on the campus of the LSE (London School of Economics), University of London. It is a sustainable architecture with intelligent integrated systems, with energy efficiency and prefabrication technologies in steel and glass, with the use of renewable energies (Fig. 1) [4].

2. Integration with Intelligent Automation

For the management of buildings, there is a

Fig. 1 Center building, Rogers Stirk Harbour + Partners, in LSE campus, London UK.
Source: photo by the author Consiglia Mocerino.

complexity of systems and technological devices that integrate, from the early stages of design, by investing in the new BIM technology. This manages to improve with digital control, all the design phases, from the realization to the maintenance of the buildings, in which the new approach is towards an efficient method of integrating both technological-structural systems for the construction realization, and for its management energy, through intelligent digital systems integrated with systems with AI implementation. With this in BIM it is possible to achieve greater planning and realization security, for the comfort and verification of problematic data in previous phases.

The help of AI becomes fundamental for the estimate of the project, before the construction of the building, aimed at the best integration of systems, services and efficiency. In this first phase of estimation, the quality of performances, the quantity of materials and components, the types of intervention with control of investment costs and ROI (return on investment), the quantity of working personnel are evaluated, projecting the organizational management in a short time with high final performance .

In the planning of the works, from the first phase of the survey of the project, a complete mapping is performed with the aid of algorithms that exchange information with drones, in the technological transformation of deep learning based on artificial neural networks in multiple layers, and in the manner of operation of the human brain, such as biological neural networks, etc. Smart buildings with a different and new integration of management systems, such as BMS advanced computerized systems capable of controlling electronic, mechanical and electrical devices are towards this trend.

In fact, these systems control and manage buildings by managing HVAC systems, the electrical system reaching almost 70% of energy use, and more. They are integrated with IoT technologies implemented by the AI on wireless networks becoming an imported methodological approach, in order to guarantee the quality of services, energy efficiency and safety. But it is also the correct design of the digital network of a connected smart building, which affects the correct functioning of the BMS, with protocols no longer closed but open, with the possibility of receiving, through predictive analysis, the data information for effective operation, ensuring rapid logistics and cost reduction.

2.1 Digital Efficiencies

In the correct functionality of the IoT network (Fig. 2) the network, which carries the information to the database from the various sensors, is distinguished in different types of connections: from hybrid systems, wired (by cable) highlighting the wireless diffusion, with information and data transmission on low frequency radio waves.

The network thus created promotes mobility with efficient modification of the devices, without losing the internet connection, scalability with network expansion, flexibility, and cost reduction [5].

It is precisely on this wireless network that artificial intelligence is integrated to increase energy efficiency in smart buildings with a 5-6% reduction in consumption in the EU. For this purpose in Italy with the Legislative Decree 192/2005, according to the

Fig. 2 Internet of Things and connection in the smart building.
Source: Ref. [6].

European Directive 31/2010/EU, public and private buildings, nZEB (near Zero Energy Building) since 2021, are compulsorily built. With a projection in 2040 of an efficiency of the buildings that reaches 40%, respect to today's ones, according to IEA 2019 [7]. Therefore efficiency policies aim at lower consumption by aiming at the digitalization of the building with wireless networks and with IoT technologies that interconnect all the building's integrated systems. They are distinguished by lighting control (with emergency signaling, etc.), HVAC control, blinds for closures, security, fire protection, leak detection systems, escalator monitoring, elevators, etc. The longer life of the systems is also recorded through the automatic detection of the reduction in energy performance, in which the quantity of energy stored and output is highlighted. For this purpose, digital efficiency is evidenced with an independent control, both of the energy consumption of the BEMS (building energy management system) and of maintenance planning of buildings with BMS, integrated with the scalability of AI. It allows the possibility of performing a calculation system in a few seconds to guarantee human interventions and possibilities, as an alternative to complex and long manual calculations with added value results for the end customer, both for construction sectors, for new construction, than for redevelopments and renovations. It also provides for active management of critical conditions, in addition to monitoring and updating systems.

2.2 Method and Technologies of the Plant Building System

The applications of these digital wireless technologies are optimized by the integration of AI in the management of the technological and environmental system of the building, with the advantage of reducing CO_2. For the purposes of energy efficiency, systems are developed according to the EN15232 standard that combines automation and energy saving with user comfort. In fact, in addition to the automation of electrical systems, HVAC, etc., the standard also indicates energy performance as an effect of the automation itself. For this purpose, a method is also established to define the minimum requirements for both automation and building management and evaluate the related effects. In particular in the area of BACS (building automation and systems)/TBM (technical home and building management) referring respectively to the systems of control and technical management of buildings, there are many applications of building automation technologies of BMS and BEMS computerized systems. These interface with several open interoperable automation protocols, including ModBus, royalty-free, designed by Modicon, and adapted on Ethernet and TCP/IP specifications, BACnet, born as ASHRAE/ANSI Standard 135 and then became ISO 16484-5, among the most widespread is LonWorks-Echelon Corporation (LonTalk and then ISO/IEC 14908) and finally with universal KNX/Konnex. They all derive from OSI (Open Systems Interconnection) as defined by ISO (International Organization for Standardization).

These are used for anti-intrusion and fire prevention systems, also involving sectors of street lighting, metropolitan networks, airport control, hospitals, and others aimed at energy efficiency, safety, control, comfort and cost reduction.

In fact, with the company INDRA, for the first time in the world, the recent solution was created in 2020, for the high-tech remote control tower, based on artificial intelligence and deep learning architectures, for the safety of the take-off phases in the airports with related operations. Furthermore, the solution is also aimed at managing multiple airports through a single operating center based on autonomous processes. As in the example of 2020, of the Bradford Teaching Hospitals NHS Foundation Trust hospital in the UK, is the first installation in Europe, where health care flows into the new GE Healthcare Command

Center. In general, in the building, for the purposes of efficiency, the different functions of the TBM lighting, heating, cooling, ventilation, air conditioning, sunscreen systems are identified, as well as those relating to the various building automation systems. Instead, four BACS classes of increasing energy efficiency are defined by the standard for the purpose of classifying automation systems,

They are from Non Energy Efficient (non efficient and traditional)-class D, to Standard (for buildings with bus and minimum performance levels, traditional BACS system)-class C, to Advanced (centralized and coordinated management of the systems, advanced BACS/TBM system)-class B. In addition to class A, High Energy Performance, in which the operation of the individual HVAC systems, is managed by building control systems, with the integration of lighting systems, blinds management, etc. is established, together with sophisticated data provided by detection systems for air quality, user occupancy, etc. [8]. For automation, with the IoT interface connection to IT, traditional communication protocols are currently identified with the IP address (Internet Protocol) such as KNX to KNX/IP, BACnet/IP, BACnet/IPv6, LON/IP, etc. with SCADA technology, etc. It also indicates the efficient method approach of the taggin that is connected to the IP network, that of information technology for open platforms, the use of control systems in buildings. Ultimately in the building system with vertical closures of different types, from curtain walls to glazed systems, and more, and internal partitions with doors and false ceilings, and more, greater control, efficiency and energy savings are obtained, through the connected artificial intelligence to BMS systems for HVAC control, Lighting, Alarm Management, Security, Maintenance Management, furthermore connection to BEMS systems for Mobile Device Ready, custom KPI (key performance indicator), Baseline, Cost Index, Bills Comparisone, and to BMSA (Building Management System Analytics) systems for real-time analysis in plants. In addition, the reporting of inefficient compartments, calculation of costs generated by inefficiency, which can be installed on existing third-party systems, and finally the creation of indices by type of system, integrated with different subsystems such as fire prevention, supervision, etc. are distinguished through open protocols.

For these building systems, however, the need arises for an apparatus for monitoring electricity consumption and centralized alarm control. For this purpose, AI therefore allows to obtain efficiency and economic advantages by exploiting data that cannot be easily reached by men, through systems that make decisions based on models based on machine learning or on the system's ability to detect and derive models. But among the major research objectives of the NIST (National Institute of Standards and Technology), in line with the "A Plan for Federal Engagement in Developing AI Technical Standards and Related Tools" 2019, there is that "to measure and enhance the security and explain ability of AI systems" [9].

3. Case Study

The Fondation Louis Vuitton in Paris, a private museum dedicated to modern and contemporary art, founded by Bernard Arnault, has also been housed, since October 2014, in a building with an efficient glass envelope, designed by architect Frank O. Gehry. This architecture is located in the Jardin d'Acclimatation in Paris, and in a recent energy requalification of Assystem, the hypervision multi-trade digital solution is adopted which mainly controls the installation of the advanced BMS management system in the building and the equipment low current.

The solution is based on the interoperability of the PcVue platform and the relative power of the front-end of communication, with capacity, in real time or on a calendar basis. This is allowed through an advanced management device, to prefigure and program scenarios in which all the building's technical systems

Fig. 3 Fondation Louis Vuitton, arch. Frank O. Gehry, Paris. Photo DR.
Source: Ref. [10].

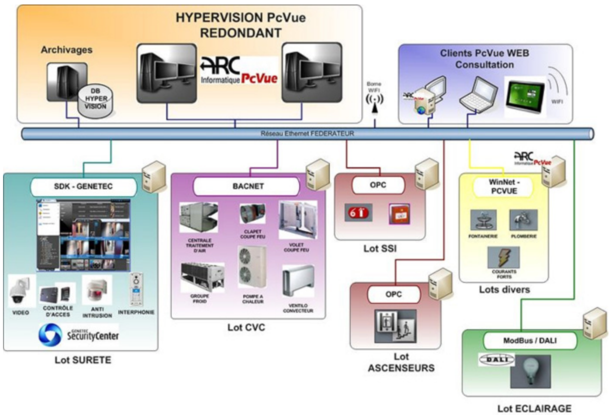

Fig. 4 Hypervision PcVue, based on different communication systems (ModBus, BACnet, SDK-GENETEC, SNMP and OPC). Fondation Louis Vuitton, Paris.
Source: Ref. [11].

participate and finally to synchronize the operation of the building's utilities (Fig. 3).

The hypervision system consists of communication interfaces with the subsystems, a mobile system, capable of controlling lighting and a scenario editor. These manage all the technical installations and then program them and make them interact in different scenarios, adopting communication systems including BACnet, SDK-GENETEC, SNMP, ModBus and OPC (Fig. 4). Access to the web is allowed on ARC Informatique's PcVue platform which represents the monitoring system for electrical systems, water system and water supply and consists of 4 client workstations, 25 WebVue licenses and 4 servers. This efficient platform integrated with the Genetec information, diffusion system interfaces with the technical infrastructure management protocols including BACnet for air conditioning, DALI for the lighting system, OPC for the fire-fighting system and vertical connection systems including elevators. The system consists of 130,000 centralized points for the control and monitoring system, with a management subsystem for the electrical supply, security, anti-intrusion, hydraulic systems, sensor systems, fire prevention system, and more.

4. Conclusions

In technological innovation, rigorous scientific tests are developed that guarantee safe, reliable AI. We also need to develop a broad spectrum of standards for AI data, performance, interoperability, usability, scalability, security and privacy already operating on open platforms. Control in buildings is a fundamental part of the new BMS digital systems integrated with subsystems with open protocols, and in which the greatest interoperability takes place with artificial intelligence, IOT and wireless networks. So in buildings, for the closings and inside of the housing, digital systems with open protocols and new intelligent technologies will be adopted to interconnect more with automation with the same systems, users and urban network. For this purpose, both IT messaging and tagging standards are used, which is connected, via the IP network, for greater efficiency of the technological design integrated with the management systems, both energy and technical in the building. The challenge therefore is of a new design method approach, with innovative intelligent systems in buildings, implemented by emerging AI [12] and ML technologies for sustainability, efficiency, productivity and cost reduction.

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