

PAPER • OPEN ACCESS

## Smart envelope and climate context

To cite this article: M Milardi and C C Musarella 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **296** 012040

View the [article online](#) for updates and enhancements.



**IOP | ebooks™**

Bringing you innovative digital publishing with leading voices to create your essential collection of books in STEM research.

Start exploring the collection - download the first chapter of every title for free.

## Smart envelope and climate context

M Milardi<sup>1\*</sup>, C C Musarella<sup>1</sup>

<sup>1</sup> Department of Architecture and Territory, *Mediterranea* University of Reggio Calabria, Salita Melissari 1, Reggio Calabria, 89124, Italy

\*mmilardi@unirc.it

**Abstract.** The construction sector today is characterized by demands for new qualities in the field of energy efficiency. This attention has taken on an even more incisive role with the European Directives 2010/31/UE and 2012/27/UE, which obliged Member States to implement actions for energy saving by paying more attention to the planning phase. The general goal of the research is to analyse the smart envelope by verifying the influence that the reference climate context has on the energy efficiency of buildings, making progress in the study of the principles of smart buildings linked to an integrated renewable energy system monitored in order to put it directly in communication with the final user. In fact, it is important not only the choice of materials, but also the right contextualization and their correct installation to provide more information for better control and more efficient energy management from the building level up to small urban areas, “matrioska effect”. The envelope thus becomes the protagonist par excellence for the correct management of energy flows both in and out.

The energy efficiency of buildings, in fact, is mainly determined by the performance of the envelopes, the efficiency of the facilities, the use of renewable energy sources, the passive control systems of winter and summer comfort. Performance that depends on various factors, such as shape, orientation, transparent surfaces, solar gains, ventilation, technological systems used, materials ... This need to design in a “renovated” has changed the concept of technical construction elements developing increasingly smart components following the rules of automation, or more specifically those of automation and management of technologies through the use of domotic for existing interactions with the climate context of reference. Therefore the research aims to develop a methodology that provides more information on the energy performance of home automation systems.

### 1. Introduction

Energy efficiency, microclimatic comfort, environmental and socio-economic sustainability can be related aspects in the design and management of building heritage. In fact, the energy quality, thanks to the growing attention offered by European and National Regulations, has become a driving force in the building sector.

In this logic, an important role on the energy level has been played by European politics<sup>1</sup> in the building sector, which refers to the EPBD Directive in its various editions (2002, 2010 until to the recent Directive No. 844/2018) for the reduction of energy consumption through the reduction of energy needs [1].

---

<sup>1</sup> Energy policy in the building sector began with the European Directive 2002/91/CE, replaced by the current European Directive 2010/31/UE and confirmed by the 2012/27/UE.



In this context, just the European Directive n. 31/2010 introduced the concept of nearly zero energy building (NZEB), defining it as:

“..... *high energy performance building ... [ ... ] in which ... very low or almost zero energy needs should be very significantly covered by energy from renewable sources, including energy from renewable sources produced locally or nearly*”.

In fact, it has been seen that the obligation to construct nearly zero energy buildings, in addition to the progressive diffusion of normative standards and voluntary protocols for high efficiency upgrading, has demonstrated the economic, environmental and social benefits of a conscious recovery.

The application of the Directives has also contributed to confirming the interest in a building characterized by high-energy performance, intended as a guarantee for the containment of consumption from fossil fuels and climate-altering emissions [2].

In this sense, the choice of construction and plant engineering technologies appropriate from the point of view of integration and compatibility with the building envelope can become necessary for energy optimization, identifying in the building envelope a primary role in the technological qualification process of architecture.

This makes the possibility to identify strategies/interventions in relation to the issue of control and energy efficiency of buildings with reference to the urban context and the reference climate. However, in order to mitigate the problems encountered within an urban context and implement the actions for energy saving, as required by the European directives, to make a significant change of scale and analyse in more detail the buildings of the urban space, not just individually, but putting them in relation with the context in which they are located.

The research aims to identify the need to develop envelope and façade systems with flexible energy performance adapted to climatic external conditions.

## 2. Background

Following the widespread recognition of the urgency of environmental issues and responsibilities related to building activity, the concept of *energy efficiency* is interpreted and borrowed in today's architecture as a foundational assumption of design choices. For that reason, the need for a renewed design has now come to the fore, combining the optimization of local resources (climatic and material) and of the internal environmental quality with innovative technical-constructive methods [3].

Within this large issue, defining processes and technologies for understanding and controlling the two-way relationship between building and context can be one of the strategies to improve the quality and performance of envelopes.

However, in the literature we can distinguish different interpretations of smart envelopes starting from Wigginton & Harris [4] that define it as a “*reactive controller that activates exchanges between the external and internal environment, with the ability to provide maximum comfort*”, or Compagno that considers it as a whole more complex of “*intelligent*” façade that is not mainly characterized by how much is guided by technology, but instead by the interaction between the façade, the construction services and the environment” [5]. In this logical it is possible to find the need to introduce models of envelopes design, also in retrofit, thought also according to “smart” logic in urban environment, in relation to climate context.

This need to design “renewed” has changed the conception of the technical elements of a building. For example, the envelope no longer has only the function of closing outwards, but it itself becomes the manager and regulator of energy flows. Therefore, also the other technological systems used regarding the closing elements towards the outside, like the gates, take on a different role and specificity [6].

In fact, analysing the envelope means verifying the influence that the reference climate context has on the energy performance of buildings. In fact, it is important not only the choice of materials, but also the right contextualization and their correct installation to provide more information for better control

and more efficient energy management from the building level up to small urban areas, thus developing a “matrioska effect”. By matrioska effect, we want, therefore, to understand the container that also becomes the content, triggering relations, even unconscious, of isomorphism, understood as correspondences between two sets. The matrioska can be, in fact, an effective metaphor useful to explain how the system of the built and the existing relationships between building and urban/environmental contexts.

In this logic, this concept of dynamism leads, therefore, to investigate the issue of smart facade systems in order to develop a new the component/skin of vertical closure that has the characteristics and the possibility of varying its configuration in relation to the *microclimatological* environment context.

### 3. Goals and scope

The growing attention to the problem of reducing energy consumption and environmental comfort has generated a multiplication of the technical and functional elements that make up the envelope that transforms from static closure into dynamic stratification, in which each layer contributes to satisfy different aspects of climatic, acoustic, energetic type, etc....

In this sense, the research aims to insert in the varied field of research conducted in the last decade on the energy performance of the architectural envelope, understood as the totality of the parts that define an internal environment (characterized by “climatic/environmental” conditions stable) compared to an external environment (variable by nature).

The research aims, therefore, to advance the study of the principles of smart building linked to an integrated renewable energy system monitored through innovative sensor systems and related data processing algorithms, which allows carrying out a precise survey and evaluation of main environmental and energy parameters. That to produce the energy/operative profile of buildings and putting it directly in communication with the reference user. This also through the analysis of the relationships between the envelope innovation process and the building-system innovation process.

Moreover the envelope need of the possibility to vary the thermo-hygrometric performance as a function of the external climatic conditions, the ability to reduce energy consumption of a building (in relations to the external climatic conditions) and to increase the comfort (thermal, light, acoustic, hygrometric) of the confined space.

The research, in particular, aims to analyse the smart envelope potential, recovering the definition of that given by R. Banham, as *advanced technological component, able to manage and regulate the material and immaterial energy flows in and out of the confined environment, through the regulation of fixed or variable-setting devices* (sunblind’s, opening/closing of windows, ventilation outlets, etc.), or with manual or automatic control and regulation in relation to the type of user and the complexity of the building [7].

### 4. Instruments and control systems: the smart approach and contests climate

In recent years, smart automation and building automation have become increasingly important, specifically automation and management technologies using systems and domotics sensors, innovative solutions for integrated management [8].

For that reason, it is necessary to analyze the concept and the domotics strategies to define the interactions between these and the reference climate.

Compared to intervention strategies used, such as the use and the integration of passive and active bioclimatic technologies; thermal insulation of buildings; interventions for the control of solar radiation and the optimization and control of the energy management of buildings through the installation of more efficient components and system; an important role that has contributed to raising the quality of life it can be attributed to electronics and information technology, through the so called CIB

(*Computer Integrated Building*) technologies<sup>2</sup>, or the discipline that deals with the plants, in buildings with the highest degree of integration [9].

This theme has developed in two directions: to the *Building Automation*<sup>3</sup> and *Office Automation*, also known as *Home automation* or *Home computing*.

The word *domotics*, in fact, is a neologism deriving from the contraction of the Latin word "domus" (house, dwelling) together with the noun "automatic" (or, according to some, to "information technology" or "robotics"), in any case say information applied to the home or translated into a single definition "automated home" or "smart/smart home" [10].

*The Smart building* is located inside the smart city, designed through various interdisciplinary aspects, with the dual aim of improving the quality of life of citizens and be self-sustainable from both an economic point of view, both energy than environmental. In this context the importance of ICT - Information and Communications Technology<sup>4</sup>- growing by the day thanks to the possibilities and scenarios enabled by IoT<sup>5</sup> - Internet of things - which plays a fundamental role where there is a need to acquire, process or transmit information.

The need to design and build smart buildings, based on the connection and relationship of different electronic components inserted into the building, depends not only on the need to reduce energy consumption and environmental impacts, but also represents the possibility of offering users better levels of comfort .

The smart building, in fact, with the support of new technologies, allows the possibility of developing a coordinated, integrated and computerized management of technological systems (air conditioning, water, gas and energy distribution, security systems), computer networks and communication networks, in order to improve management flexibility, comfort, safety, energy saving of buildings and to improve the quality of living and working inside buildings.

A home automation system consists of three functional elements: a device called intelligence, interfaces and communications.

- The intelligence device, component that develops and manages the relationships between devices and interfaces;
- Interfaces , elements of interaction necessary to be able to perform actions within the home automation environment;
- Communications, which allow the elements of intelligence to communicate with each other or with the various devices of the system.

However, it is evident from literature that the design of an energy efficient building uses design strategies that refer to the bioclimatic architecture [11].

In particular, we refer to the context and orientation of a building, the form of a building and to the heating and cooling system, both passive and active.

---

<sup>2</sup>CIB technologies include all the automation and control systems, safety systems, telecommunications, etc., organically integrated into the building, upstream of its own construction (to avoid subsequent problems related to wiring, maintenance, management costs), which are then integrated into the project phase, which means that the means available at the technological level and the client's objectives are always present, since the characteristics of the "smart building" cannot be separated from one or the other. CIB is in other words a "system of systems", specifically studied, designed and finalized. More precisely, it is the integration of four technological areas: control systems and management of technological systems, security systems, distributed IT systems and communication systems

<sup>3</sup> Building Automation allows the automation and efficiency of the functions of a building, which becomes a more or less complex ecosystem of connected devices. Each plant is intelligent in itself, but works with others in an integrated way, because what makes a building smart is actually the control and the integrated functioning of its components.

<sup>4</sup> Information and Communication Technologies or ICT are the set of methods and techniques used in the transmission, reception and processing of data and information (including digital technologies).

<sup>5</sup> Internet of things is a neologism referring to the extension of the Internet to the world of objects and concrete places.

The energy efficiency of buildings, in fact, is mainly determined by the performance of the plants, by the use of renewable energy sources and by passive control systems of winter and summer comfort. Performance, however, that depends on several factors, such as shape, orientation, transparent surfaces, solar gains, ventilation, technological systems used, materials...

For that reason, the local climatic context and the "position" of the sun throughout the year is of great importance. In winter, in fact, there is a need to heat the buildings, so the most used strategy is to capture the available solar radiation; in summer, however, it is necessary to reduce the solar gain to a minimum, as the excess of heat goes to attack the interior comfort of the building and the need to use cooling systems [12].

## 5. Methodology

From what has been said, it is clear in that the majority of the energy needs of a building is compensated by solar gains, for which energy consumption in buildings controlled orientation is of paramount importance.

The correct orientation and an intelligent layout of the premises can offer guarantees of comfort for all seasons, without necessarily exceeding the need for energy-intensive mechanical solutions. It is therefore necessary to choose carefully the orientation of a building in order to reduce as much as possible the energy needs of the building.

Designing smart, in fact, means paying attention to the boundary conditions in order to "exploit" the resources that the environment offers, aiming at the same time to control three levels: climate - environmental, typological and technical-constructive [13].

This research aims to verify the energy performance of the component during the use phase with respect to the reference environmental context, specifically considering solar radiation (UNI 10349) in relation to the cardinal points, comparing it to the thermal conductivity of the materials of the smart components, in order to establish the energy performance of the smart component with respect to orientation by providing more information to the home automation system.

Therefore, the reference climate context and, in the specific the orientation through the solar radiation, can be defined as a fourth functional element so that the envelope becomes a smart system and is designed as such, i.e. as an element of automation integrated with different building systems, like those of accumulation and production of renewable energy, which helps trigger significant benefits either direct or indirect.

Among the direct benefits there are the energy management (reduction of bills) and of comfort, to building scale. Indirect, while, can be define those advantages that can be found in the long term on an urban scale. In fact, the multiplicity of buildings designed with smart envelope systems that are able to relate to the reference climate context, as well as with users, leads to an energy and environmental improvement and urban scale.

## 6. Conclusions

All of this confers that the environmental issues carry on the envelope and its design complex and extreme importance finalization. The concept of high performance, in fact, not only relates to energy issues and nor can it be attributed exclusively to the envelope, but to its systemization. The envelope, in fact, become a key element in the continuation of innovative research developments.

In this perspective, the envelope represents the physical element of mediation between the external and internal environment: it responds to the signals that qualify the external environment, contributing to becoming an element of transformation and control.

In this regard, *smartization* and *home automation* it is increasingly developing, becoming a valid help in managing the operation of buildings, and helping to ensure coordinated control of the plant and all those devices that can improve the quality of life in the home.

Home automation, in fact, can make use of the multiple information that allow the integration and automatic management of security and facilities, and the consequent energy optimization.

Therefore, the realization of envelope, considered also as an element of mediation between the reference climate and the user, can become a goal of the change of cultural and planning paradigm.

From the foregoing, furthermore, it is possible to understand how the façade components have to be analyzed with respect to their stratigraphy, contextualization of climate and exposure in order to increase information on the management of their energy performance and help users to collaborate in the reduction of energy resources.

In fact, there is a growing need to elaborate an innovative dynamic reading of the information available to have more indications for the energy contraction of buildings and, consequently, of urban areas.

In fact, from the first results developed, is clear that is increasingly evident the need to develop an innovative dynamic reading of the available information to have more indications for the energy contraction of buildings and, consequently, of urban areas.

Work in progress.

## References

- [1] COMMISSION RECOMMENDATION (EU) 2016/1318 on nZEB buildings.
- [2] Bollini G 2013 *The new Directive 2012/27/UE on energy efficiency in a zero* no. 06, p. 6-9.
- [3] Rossi M 2008 Prodotti e sistemi di involucro innovativi per il progetto di edifici energeticamente efficienti. Procedure, simulazioni termodinamiche e criteri progettuali per un'applicazione nel Sud Europa. *PhD Thesis* Università di Napoli Federico II.
- [4] Wigginton M and Harris J 2002 *Intelligent Skins*, Eds. Architectural Press (Oxford).
- [5] Compagno A 2002 *Intelligent Glass Façades*, Eds. Birkhauser Publishers (Berlin).
- [6] Lucarelli M T 2010 *Sustainable management of energy resources in the construction and plant sectors* Ed. CSd'A University Press Center (Reggio Calabria).
- [7] Banham R 1969 *The Architecture of the Well-tempered Environment* The Architectural Press (London).
- [8] Milardi M 2014 *Pattern of technology integration systems to the deferred energetic control of the building envelope* in the Proceedings of 40th IAHS World Congress On Housing - Sustainable Housing Construction, Funchal, Madeira, 16/19, December, 2014.
- [9] Agnoli S and Zinzi M 2013 *Transparent envelope and energy efficiency - Technologies, services and environmental control* Eds Flaccovio (Palermo).
- [10] Vandi S 2015 *Smart home: Stato dell'arte della tecnologia*. [Laurea], Università di Bologna, Corso di Studio in Ingegneria elettronica, informatica e telecomunicazioni – Cesena.
- [11] Tucci F 2014 *Envelope, Climate, Energy*. Bioclimatic quality and energy efficiency in architecture in the environmental technological project of the skin of buildings/Envelope, Climate, Energy. Bioclimatic quality and energy efficiency in architecture in the environmental technological design of building skins, Altr Alinea Editions, (Florence, Italy).
- [12] Herzog T 1996 *Solar Energy in Architecture and Urban Planning*, Prestel Verlag, (Munich-New York).
- [13] Casini M 2014 *Smart Building Casing 2.0* . Ed. DEI , (Rome), November.