Smart and Healthy Buildings

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Abstract. Nowadays the smart structures and materials utilization are expected. A great smart approaches investigation presented by smart technologies, materials, structures etc. is done. The design of structures and buildings include the advanced structural components with the smart properties to provide the automatic control and management while being integrated into the networked electronic system. It is clear that using the smart structures and design the smart buildings are important actual approaches. The integrated smart approach will change the engineering practice in the environmental manner. The smart buildings also make it possible to optimize processes, reduce costs and increase the environmental safety. The smart design approach makes the innovative solutions possible for every building and every expectation of indoor environment quality. Additionally, a multidisciplinary interactive top-down approach is required to facilitate the design, construction, maintenance and operation of a smart building, in which the architect, as well as the other stakeholders, fulfil a new or a different role. It is important to accept that IEQ is a multi-level, multi-factor and multi-stakeholders issue, therefore, the cooperation is a must.

1. Introduction

The environment quality has become a major issue in the concerns for healthy buildings. Indoor environmental problems have four common causes, and more than one may be active at any time: an inadequately cleaned or maintained environment, insufficient ventilation, pollutants emitted from sources and activities inside the building and contamination from outside sources. These causes can often intensify or add to the stress that occupants suffer from inadequate temperature or level of air change. The right design for and selection of the HVAC-system is extremely important from the hygienic thermal condition. Therefore, it is obvious that the indoor environment becomes at present the matter of broad interest. Indoor thermal comfort and indoor air acceptability are in consideration of specialists. The indoor air quality must nevertheless be the guiding factor for building design.

The problem of achieving healthy and comfortable buildings is well recognized by the scientific community. The built environment is the place where people spend 60-90% of their life [1], (European Commission, 2011) and where about the 40% of the European energy is consumed [2], (European Commission, 2009), also to maintain and guarantee the required living quality.

Previous studies have shown that the relationships between indoor building conditions and wellbeing (health and comfort) of occupants are complex [3-5]. There are many indoor stressors (e.g. thermal factors, lighting aspects, moisture, mold, noise and vibration, radiation, chemical compounds,
particulates) that can cause their effects additively or through complex interactions (synergistic or antagonistic). It has been shown that exposure to these stressors can cause both short-term and long-term effects.

With the dramatic increase in the world’s energy use, both existing and new buildings should be built with renewable energy sources and with smart energy systems at their core by integrating Distributed Energy Systems (DES). It is a term coined to encompass an array of energy generation, storage, monitoring, and control solutions. DES covers energy in the forms of electricity, heating, and cooling, thus offering building owners and energy consumers various opportunities to reduce cost as well as improve the reliability and security of additional revenue.

The idea of energy efficient, healthy and smart buildings have been around for a long time, so why is it just now that the concept of green or sustainable building is entering the mainstream and catching the attention. There are probably several reasons: global warming, rising energy costs, the growing awareness and liability costs associated with sick building syndrome, declining oil reserves, and concerns about our limited natural sources. The list goes on, but whatever the reasons, the sustainable smart building is a concept whose time has come. However, the words green and sustainable are often used interchangeably, and sustainable has a more precise meaning that is often obscured, distorted, and diluted by the commercialization and marketing of the green movement. The ultimate definition depends on how one defines green as opposed to how one defines sustainable. The green building definition is relatively simple. A building’s design is green if it serves to reduce many of the harmful impacts the buildings have on the environment and on the building’s inhabitants.

The smart building concepts have existed for some time, even though the exact definition of a smart building may have seemed elusive. The smartness rightfully implies a form of intelligence. Thus, the recognized need for smart buildings likely represents an indictment on the relative lack of intelligence in buildings today. This lack probably points to the desire for more intelligence and the basis for today's Internet of Things (IoT) smart building trends. 2019 has arrived with even higher expectations from smart building technologies. Many believe that smart buildings will provide greater connectivity in building systems. Certainly, buildings contain complex mechanical Heating, Ventilation and Air Conditioning (HVAC) systems as well as control systems that can improve the comfort, hygiene and environmental safety of building indoor environment. Smart building technology can, therefore, provide the means for greater levels of integration between existing building systems. We expect that to increase as open standards continually pave the way. State the objectives of the work and provide an adequate background, avoiding a detailed literature survey or a summary of the results.

2. Smart buildings
Smart building construction can be introduced as smart envirosystem system which has its own function and continual automatic control. The smart engineering envirosystem has the ability to answer on actual basic function requirements. The envirosystem is an environment with which the subject is in interaction. It is the field of transfer with which the subject is in direct interaction without intermediation of other components of the reality. The exploitation of smart materials is expected to influence significantly the further evolution of smart building design. In this presumption, the intensive research of smart structures and smart materials is taking place. The gradual informatics interactive communication between research areas creates appropriate prerequisites for conceptual research solution as a whole. At the same time, the smart engineering scientific branch is coming into being. This multidisciplinary branch involves knowledge about materials, construction, sensors and operation systems, etc.
The smart structures are not clearly assessed so far. More or less it can be derived from biological models, which have sensors reacting like the nervous system, actuators working like muscles and operating system reacting like a brain (Figure 1).

![Figure 1. Schematic demonstration of smart structures functioning](image)

A significant part of every single scientific branch evolution is the definition of activities and uniformity in concepts. The problem is similar in smart engineering – how to ensure a simple concept classification. The basic division of smart materials and smart building construction is needed. The materials are taken for smart when they are reacting and modifying their response in dependence on the environment. Smart building construction may be understood as a system of sensors and actuators which together with operating and controlling system are keeping the structure in a certain state or given structure reacts according to fixed rules.

A building is strongly influenced by structures and materials applied. If we want to have a smart building, we have to design them smart and to make them smart. The smartness of a building is manifesting itself during the design, construction and exploitation. As a building architecture is characterized by factors as function, aesthetics, economy and engineering, smart buildings have their characteristic features (Figure 2). The smart building has to use smart structures, has to be low energy building, healthy building, automatics service controlled building and economic effective. The indoor technologies make every building a smart building generally. This enhances the user experience and convenience of your employees, visitors, patients and/or suppliers. The smart indoor technologies in the building help us to make the buildings more comfortable and healthy. The building becomes easy for using and the right operation of indoor services systems. Today’s HVAC technology offers the modern homeowner more options that make it much easier to meet your family’s unique indoor comfort needs. Modern HVAC systems are becoming more and more energy-efficient, and you can choose a heating and cooling system that uses advanced, environmentally-friendly technology.

Analyzed specific features of smart buildings and factors which influence them will always be expressed by physical parameter. To achieve the required characteristic of smart building, expressed by physical parameter, these main groups of tools are existing:

- Architectonic and essential technical concept of a building
- Detail and architectonic or construction element of a building
- Environmental engineering of a building, including indoor engineering
- Operating systems and controlling systems of a building.
3. Healthy buildings
As stated above, the smart building has to be healthy. In order to design healthy buildings, the criteria have to be listed and the approach has to be clear. Some factors for healthy building criteria are evident in Table 1.

Table 1. Factors for healthy building criteria

| Environmental focus                  | Criteria focus                                      |
|--------------------------------------|-----------------------------------------------------|
| Indoor environmental quality         | Thermal comfort                                     |
|                                      | Indoor air quality illumination                      |
|                                      | Acoustic                                            |
|                                      | Security                                            |
|                                      | Privacy                                             |
|                                      | Way finding                                         |
|                                      | Functional support                                  |
| General environmental quality        | Energy consumption                                  |
|                                      | Natural resource consumption                        |
|                                      | Mineral resource consumption                        |
|                                      | Land use                                            |
|                                      | Air pollution                                       |
|                                      | Water pollution                                     |
|                                      | Soil pollution                                      |
|                                      | Biodiversity loss                                   |

It can be seen that the list, although it encompasses only fairly broad categories of indoor environmental factors, is rather lengthy. When the details of each of these factors are articulated, it is clear that the design of healthy buildings is a complex task. While data and standards exist to guide
design relative to the separate factors there is little guidance for designers that allows understanding of the complex interactions among these factors and the combined effects of multiple environmental exposures on building occupants.

Human respond to all facets indoor environment: the human body integrates its response to environmental factors as mediated through various receptors) visual, tactile, aural, thermal and posture. Most research separately addresses these various receptors and the related human responses. Standards and criteria generally available for design are derived from this focused research. Very little research has still addressed the interactions among the multitude of factors. Thus, designers are challenged to discover the interrelationships among the various factors and ascertain the effects of interactions among environmental factors and the human responses to them. This is not a trivial task, and little guidance exists to asset designers effectively to address the inherent problems.

The healthy building design revolves around mainly these key issues:

- Designing for energy efficiency including the use of renewal energy sources such as wind, geothermal, and solar.
- Creating a healthy indoor air environment with adequate ventilation and making material choices that minimize volatile organic compound (VOCs) outgassing within the building.
- Specifying building materials and resources that are sustainable, have low embodied energy, and produce a minimal amount of upstream environmental impact.

In the context of global warming and even the most optimistic projections of peak oil and gas, only a building that meets zero energy standards can be considered sustainable.

4. Indoor environment

For the assessment of health and comfort risks of people have when staying indoors, it is clear that a different approach or procedure seems inescapable. A different view on indoor environment quality (IEQ) could help to better understand the indoor environment and the effects on people. A view in which IEQ is approached in an integrative multi-disciplinary way, taking account of possible problems, interactions, people and effects, focusing on situations rather than single components (Table 2) [6, 7].

| From                                           | To                                           |
|-----------------------------------------------|-----------------------------------------------|
| Attention directed mainly to negative impacts | Attention to positive and negative impacts    |
| Insight in a single dose and response relationships | Insight in interacting parameters         |
| Distributed knowledge on effects on IEQ       | An integrated framework on IEQ               |
| Ad hoc collection of recommendations to improve IEQ | An integrated approach for IEQ improvement |
| Ad hoc communication of possible roles for different stakeholders | An integrated approach which provides insight in the tasks for all stakeholders |
| Management of incidents                       | Integrated risk management                   |

Although previous studies have shown associations between indoor stressors and comfort, health and hygiene, relevant relations between measurements of chemical and physical indoor environmental parameters and effects have been difficult to establish. This may be explained by [8]:

- Many exposure-response relationships have not yet been (sufficiently) quantified or identified.
- Little is known on the complex interactions between risk factors (or parameters) in the indoor environment and effects are not all known.
• Other factors other than indoor environmental aspects (e.g. social and personal factors) may influence the effects.
• Exposure and response may be time dependent (e.g. daily, weekly and seasonal patterns).

5. Conclusions
The top environmentally friendly smart building trends can be defined as paving a path for smart building sustainability via net-zero buildings; making smart buildings resilient against climate change; confluence between the smart buildings and distributed energy systems; indoor air quality monitoring.

The number of net-zero certified projects designed to neutralize or positively redress the carbon emissions, water consumption, solid waste to landfill and their impacts on the ecology will continue to rise. Extreme climate conditions have become a reality around the world. Protecting the buildings will become a significant area for growth as more building owners take calculated measures in the design and construction of their buildings to mitigate the environmental damage. A smart energy building is, therefore, able to integrate the distributed energy systems into its design and operations according to users’ requirements to the lower energy costs, increase energy efficiency and secure energy supply while reducing carbon emissions. An increased focus on health and wellbeing, the indoor air quality will become a prominent area for growth in the smart buildings. As enterprises tenants and business focus on workplace productivity IAQ will become a popular area for innovation. More attention will be taken to IoT-based solutions which provide economical means of enhancing and monitoring IAQ in real-time.

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