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Management innovation in designing buildings: from sustainable and intelligent buildings to inclusive buildings. A survey

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Abstract

Over the last years new technologies and management concepts emerged. These tools represented the foundation of the implementation processes that created products and services that comply with every need, necessity or desire one could have. Designing buildings is no stranger to innovation, as there appeared concepts like sustainable and intelligent buildings. The main idea of this paper is to expose the buildings' designing trends, from sustainable to intelligent buildings, but also the embracement of a new concept, the inclusive building. This new concept is tightly tied to the increasing number of disabled persons and to the aging of the world's population. In other words, the population's needs can no longer be satisfied just by intelligent and sustainable buildings, constructions have to be inclusive too. Practically, this paper presents an innovative way of obtaining the ideal building: an inclusive building that complies with the specifications of sustainability and intelligence.

Rezumat

În ultimii ani au apărut noi tehnologii și concepte de management. Aceste instrumente au reprezentat fundația proceselor de implementare care stau la baza creării de produse și servicii care sunt conforme cu fiecare nevoie, necesitate sau dorință pe care o persoană le-ar putea avea. Proiectarea de clădiri nu este nici ea străină inovației, iar o dovadă a acestei afirmații este apariția de concepte precum clădiri suntenabile și clădiri inteligente. Principala idee a acestei lucrări este să prezinte noile tendințe în proiectarea de clădiri: de la clădiri sustenabile, la clădiri inteligente, dar și adoptarea noului concept, acela de clădire incluzivă. Acest concept există în strânsă legatură cu creşterea numărului de persoane dizabilitate la nivel mondial și cu îmbătrânirea populației globului. Cu alte cuvinte, nevoile populației nu mai pot fi satisfacute doar de clădiri inteligente și sustenabile, ele trebuie să fie și incluzive. Practic, această lucrare prezintă o metodă inovativă de a crea clădirea ideală: o clădire incluzivă care satisface specificațiile de sustenabilitate și inteligență.

Keywords: sustainable building, intelligent building, inclusive building, innovation management, smart cities

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1. Introduction

In the 1950s Maslow introduced the concept called "hierarchy of needs". According to this theory, every individual, in order to survive, has certain needs that can be ranked. The necessity to have a roof over one's head is a primordial need [1]. According to him, a human cannot evolve in satisfying his other needs only after the primordial ones are accomplished [2]. Growing and developing as individuals is at the basis of our evolvement, our society.

One of the prime elements we have to consider when constructing a building is the environment that is created alongside. The undoubtable effect a building has on its occupants is a small characteristic through which architecture defines itself. Another part of architecture is the exterior environment a building conceives [3].

Our following article is comprised of 8 sections. It starts with describing sustainable buildings, afterwards intelligent buildings and furthermore inclusive buildings. The next sections try to embody the current aspects existing on the market (the bond between intelligent and sustainable buildings, between intelligent and inclusive buildings and last, but not least, between inclusive and sustainable buildings). Going forward in our research of the paper we propose a new type of buildings, one on which no prior research accomplishments are found in international literature, a type that complies with the market's needs, but most importantly, it complies with intelligent, sustainable and inclusive building characteristics.

2. Sustainable buildings

2.1. Definitions and concepts of sustainable building

In the last 200 years the world's population multiplied by 9 [4]. Therefore, if in the past resources were abundant and more than enough for everybody, the last years have conjured debates of how people should use the limited amount of resources at hand. The construction industry, along with many other industries, started being inspired and absorbed in designing radical and revolutionary buildings that produce resources like water and energy, while being protective of the environment. This new trend materialized in constructing the so called sustainable buildings.

When designing a sustainable building, one has to make sure the respective building produces energy and water, the building's site is used at maximum capacity, all the resources used in construction and afterwards are used efficiently and one has to make sure the new building will safeguard the inhabitants' health and increase their productivity. Protecting the cultural and archeological resources will be another aim, along with protecting plants and animals, while making sure the carbon emissions are low [5]. In a report made by the United Nations to the World Commission on Environment and Development (WCED) is stated that sustainability is a way of satisfying the current needs of the population without deteriorating the future needs and aspirations of the generations that are about to come [6]. The three pillars of sustainability (environment, economy, society) must collaborate if the aim is to acquire sustainability [7].

There are many definitions of sustainability, but there is one thing the practitioners in the field agree upon: sustainability is synonym to energy efficiency [8]. When considering energy efficiency one has to take into consideration several aspects: the orientation of the building, its insulation system, solar protection and control, the building's weight, print, its setting and layout. Scott [66] considers that when talking about sustainability we can not only take into consideration energy efficiency, we also have to debate cost reduction and the well-being and comfort of the inhabitants.

There are six basic principles that govern the concept of sustainability, agreed upon worldwide: optimized construction site, optimized use of space and materials, improved interior environment, operation and maintenance of the building will be optimized, water management and protection, efficient use of energy [8].

2.2. Standards and initiatives

The European Union legislated one of the most important sectors of economy, a sector responsible for creating 20 million jobs. *EU2020 Strategy - Communication on Sustainable Buildings* [9] is one of the most influential strategies. One of the most important problems the European society faces in terms of construction is also the most important aim of the strategy: reducing the use of materials in buildings. The strategy tries to reduce resources like energy, water, materials, land and energy incorporated in the manufacturing process, starting from the extraction phase, to construction, demolition and recycling, practically the entire life span of a building. As a conclusion, this strategy encourages constructing sustainable buildings and their market growth. *Communication on "Strategy for the sustainable competitiveness of the construction sector and its enterprises"* [10] comes as an extension to EU2020 Strategy and takes into consideration the economic crisis, disloyal competition between non-European companies that activate in this field and European ones and the global aim to protect the environment while elaborating strategies that help the construction sector build sustainable buildings. In order to achieves these objectives, the strategy marches on 5 directions: the creation of favorable conditions for investing in constructions, qualifying labour, supporting the internal European market of construction, protecting the environment and efficient use of resources.

Regarding the consumption of energy, considering 40% of the European consumption of energy comes from buildings, there are several directives enforced at European level. One of the most important is *Energy Performance of Buildings Directive II* (EPBD II) [69] that stipulates that by 2018 all public buildings and by 2020 all private ones will have to be zero energy buildings. This directive enforces that some minimal requirements regarding the efficient consumption of energy have to be made in each country, considering costs and climate conditions. Another directive, the *Energy Efficiency Directive* (2012/27/EU - EED) [67], is a European Union's directive that is considered to be the most important helping tool in developing the energy policy in EU. This directive supports EU2020 Strategy and wishes to encourage and foresee future improvements in the energy sector. All EU member states are obliged to use energy in an efficient and rational manner, on the entire chain, from production to the beneficiary, in order to achieve the targeted aim for the year 2020. According to this directive, European states are required to report every 3 years a *National Energy Efficiency Action Plan* [68]. This plan should comprise measures to reduce the energy consumption in accordance with the objectives set by the European Union.

US Green Building Council and The American Institute of Architects created the *International Green Construction Code (IgCC)* [70], a standard created to legislate the construction of commercial buildings, either new or existing. The two main objectives of this standard are to reduce the energy consumption and CO2 emissions. In order to implement the desired objectives, this standard prospects the construction site, conservation of materials and natural resources, the use of sustainable energetic systems, conserving and collecting water and the use of energy efficient equipment. The *International Energy Conservation Code* (IECC) [71] is a model code used in construction in the United States of America. Flexibility is the key word describing this code, taking into consideration the fact that it supports and encourages the use of innovative methods and technologies in order to efficiently use energy during the entire life span of a building. *ICC 700 National Green Building Standard* [72] is the first standard with regard to designing green buildings ever approved by the American National Standards Institute (ANSI). Its domains are: designing the construction site, efficient use of water, resources and energy, maintenance and operating the

building, high quality internal ambient and training the owners on efficient use of energy.

When considering initiatives that encourage and endorse constructing sustainable buildings, *The World Green Building Council (WGBC)* [11] must be mentioned. This international network bridges councils positioned in over 90 countries in developing and applying environment policies in the building industry. WGBC is believed to be the most prominent of the organizations in the field of sustainability. *Leadership in Energy and Environmental Design (LEED)* [12] is the best known certification program world-wide and operates under US Green Building Council's government. Whether we mention houses or neighborhoods, LEED aims to promote design, construction, exploitation and maintenance of green buildings. When building green, one has to have in mind: energy efficiency, careful selection of construction materials, sustainable construction site, high quality of the internal environment and water efficiency.

BREEAM (Building Research Establishment Environmental Assessment Methodology) [13] is one of the oldest and most used mechanisms of assessing the sustainability degree of a building. Stating a building is sustainable, in their opinion, means the building was carefully analyzed on aspects as: pollution degree, water management systems, environment consciousness, energy and resources consumption, CO2 emissions, safety of the occupants and their health. Besides these factors, the building's adaptability to needs and technology is also an important issue.

The Green Building Initiative (GBI) is a non-profit organization that concentrated its work on urgently developing sustainable buildings, buildings that are energy efficient and promote the health of their inhabitants. This organization has a specific rating system for commercial buildings called *The Green Globes System* and one for institutions, called *Guiding Principles Compliance Initiative* [73]. The first one is an online protocol tool for verification, counseling, advisement in designing sustainable commercial buildings. The second assists federal agencies with support, information, documentation and expert opinions in developing high performance sustainable public buildings.

The United Nations developed and initiative called *United Nations Environment Programme's Sustainable Building and Climate Initiative (UNEP-SBCI)*, an initiative that promotes sustainable practices and policies world-wide [74]. UNEP-SBCI is basically a partnership between the main actors involved in the public and private sectors. Its mission is to create a global platform that defends the common goals and the mission of the parties involved. Another initiative aimed at the build environment is *International Initiative for a Sustainable Built Environment (iiSBE)*. iiSBE [75] is an international non-profit organization that wishes to ease the adoption of sustainable tools, practices, policies and methods and desires to create business bonds between the specialists in the field in order for one to know the other's needs and capabilities.

2.3. Technologies used in designing sustainable buildings

There are tremendous amounts and types of technologies used in constructing sustainable buildings.

Some of the most important categories are:
Eco-materials: these materials are different from the conventional materials [14] because they are considered to be of high productivity, high performance, during the process of fabrication the impact on the environment is low or none, they are recyclable, they are made out of non-perilous substances and they are meant to purify the environment.
Thermal and sound isolation: roofs and walls of mineral wool boards, doors and windows with sound insulation, products made of rigid polyurethane foam, of wood fibers, of extruded and expanded polystyrene, of wood fibers, of cellular glass etc. [15], [16]
Technologies that secure electricity: solar panels and solar power plants, wind plants, geothermal plants, thermo marine plants, biomass plants, solar panels etc. [4]

Thermal energy technologies: geothermal plants, thermo-solar plants, photovoltaic panels, heating plants that work on waste or plants etc. [4]

3. Intelligent Buildings

Modern society was shaped through the unprecedented evolvement of technology and the appearance of global communication networks [18]. The most declivitous of environments was inhabited by people due to the progression of technology.

3.1. Definitions and concepts of intelligent buildings

The market of intelligent buildings is growing rapidly all over the globe. However, the clearest of evolutions can be seen on continents like Europe, Asia and the United States of America. The richest countries, like Germany or Qatar invest fabulous amounts of money on intelligent control systems [19] that are integrated in the design of intelligent buildings.

The concept of intelligent buildings evolved in time, gradually introducing the concept of network displays and equipment. At first, in the 1970s, the intelligent building term defined an energy efficient building. Later on, in the 1980s the term meant a building that could be controlled by a computer. In 1991 an intelligent building was a building that responded to the changing needs of the inhabitants. From 1992 until now an intelligent building is a building that has components that are capable to efficiently and effectively satisfy ever-changing needs [22].

One of the first complex definitions was given by IBI (Intelligent Building Institute), (Anon. 1988, Anon. 2001g, Brown 2001, Lehto et al. 1993, p.12.). This definition states that an intelligent building is a building that provides productivity through the optimization of four elements: systems, structure, services and management and through the interrelation of these. An intelligent building helps inhabitants and owners understand long term aims with regard to costs, comfort, safety, flexibility and market value.

Leaman and Bordas state that "an intelligent building is one that doesn't make its occupants look stupid" [21] when interacting with it. In Himanen's opinion an intelligent building is a building that comprises certain characteristics: the needs of the inhabitants and of the owner are satisfied, all the systems in the building are efficient in operating, the entire life span of the building is taken into consideration, focuses on economy and latest technologies while caring for people and sustainable development and has operational environment that accommodates the structure and the systems altogether [22].

These buildings are defined by a series of characteristics [23], among which, the most important are: adaptability, technology, sustainability, health, owner's and inhabitant's needs and desires. More so, in defining the intelligent building one has to have in mind the entire life cycle of the building: design, construction, post-construction evaluation. This means all the parties involved in constructing a building must have a shared vision and must cooperate every step of the way. They must find the optimum solution for every issue in order to satisfy the evolvement of technology, social trends and owner's needs.

Integration is automatically implied when mentioning intelligent buildings. The coveted outcomes can be obtained only when the people, the processes and the products are integrated. The role of integration is to reduce costs, limit resources and improve the lives of the inhabitants. All the systems in the building must be integrated in order to have control and interoperability. In order to obtain all these, a building must have a management system. The management system is imperious to be accessible by the inhabitant in order to fully control it if need be and understand it and its

functions in order to use it efficiently and at maximum of potential.

Life in an intelligent building must rise to the inhabitant's expectation so as to be an experience for all the senses. This experience can be reached only when buildings cumulate a series of characteristics: freshness of ambient temperature, evenly distribution of fresh air, acceptable levels of CO2, natural non-blinding light, acceptable noise level, ergonomics in accordance with the work performed in that building, minimized pollution from external sources [20], [24].

An intelligent building's components can be organized in four divisions [24]:

- Facility management – is in control of operations like services' management (electricity, HVAC, access control), planning and supply, while making sure systems exchange information for optimal performance
- Information management – in charge with accumulating, aggregating and deciphering information
- Connectivity – exchange of information
- Overall control – all the systems are integrated in a building in a main distribution network

3.2. Standards and initiatives

When mentioning standards in intelligence, the most prominent one is *KNX Standard* [25] [26]. A network communication system that interconnects all the management systems in a building is at its basis. KNX ensures the control of all the building's systems, a unit control or a control centre being unnecessary. Whether it is the lighting systems, the energetic system or the security one, KNX helps them communicate through a stereotyped common language.

BS EN ISO 7730:2005 Standard - Ergonomics of the thermal environment [76] is an international standard that estimated the comfort/discomfort degree of a person when exposed to a medium temperature and can pinpoint the satisfactory temperature to aim thermal comfort. According to this standard the factors that contribute to thermal comfort are: humidity, radiant temperature, air temperature, air velocity, clothing and the activity performed by the inhabitant. The majority of these factors can be controlled in an intelligent building with the help of technology.

Another standard is *TIA/EIA-862 Building Automation Systems Cabling Standard For Commercial Buildings Standard* [77]. This standard is used in commercial buildings and refers to the design and installation of the general cabling system used in an intelligent building: basis structural cabling, horizontal cabling, coverage area, telecommunications' room, equipment's room, administration, entrances.

IP500 Standard [27] [28] is considered to be the only standard for wireless technology that ensures interoperability. IP500 is in charge with facilitating maintenance and administration of the building by making sure the appliances used for alarms, safety and control work accordingly.

Building information model (BIM) is at the basis of *ISO 16739:2013 Standard*. This standard is international and is applied in areas like: (1) defining the format of BIM data asked for every aspect of a building's life: feasibility, conceptual design, finances, construction, maintenance and operation, (2) defining the format of BIM data asked for every branch in a building's life: architecture, engineering, acquisitions, equipment management, project's management, approvals and clearances and (3) defining the format of the BIM data: the body of the project, psychical and spatial components, resources, involved parties etc. [78].

With respect to the initiatives that regard intelligent building, one of the most important is *European Initiative on Smart Cities*. It was conceived to reach the goals set by the European Union

concerning the diminishing of energy consumption and environment protection in areas like energy, transport and buildings. In this initiative's opinion, aims like zero energy consumption and zero carbon emissions can be achieved through specific strategies and policies that support the latest technologies [29], [30].

European Innovation Partnership on Smart Cities and Communities (EIP-SCC) is another European initiative that expects all the interested parties in constructing a building to corroborate in effort and knowledge and drives engineers to use intelligent technologies [31], [32].

A non-profit organization in America, *The Smart Buildings Centre (SBC)* [79] dedicated its work to developing, growing and innovating the energy efficiency industry. SBC is considered to be at the midst of industry's affairs and concerns in areas like: gathering resources in order to improve the industry's life and supporting and increasing the visibility of the companies that support energy efficiency.

BuildingSMART [80], previously known as International Alliance for Interoperability (IAI), is a non-profit industry-oriented organization. Its main concern is to initiate the construction industry into intelligent collaboration tools based on models. Other activities are: developing standards, instruments and methods to use this concept of models. BuildingSMART recommends the use of Building Information Modelling (BIM), a process through which designers, engineers and owners of two or more buildings that interrelate can use common resources more efficiently.

3.3. Technologies used in designing intelligent buildings

There are four elements that comprise an intelligent building. Each of them relies on different technologies in order to be optimized [33]:

- Structure: thermal insulation, multiple layered windows filled with inert gas/air, roof made of natural materials, dynamic facades, walls with reflective surfaces [34]
- Systems: wind ventilation systems, natural ventilation systems, heat recovery ventilation systems, boilers, heat pumps, reversed heat pumps, solar or geothermal energy systems, variable distribution of air systems, CCHP – Combined Cooling, Heating and Power Plants [34]
- Services: voice, video and data communication (through telephone, e-mail, Bluetooth, wireless sensor networks, speakers etc.), security management and safety management (emergency communications, access control, detection of smoke and fire, monitoring the interior and the exterior of the building), administrative automation [4] (all computers, information and data bases are connected through a local area network at the disposal of all users)
- Management: a system that is connected to the internet and is able to work on several platforms and protocols and who collects and caches information and gives warning in case perils are detected [4]

4. Inclusive buildings

4.1. Definitions and concepts of sustainable building

Due to the technical progress and innovation in most of the fields, the desire to fully include disabled persons in society emerged. Starting with the 1990s the governments all over the world realized that the responsibility of including disabled persons into society lies not only on doctors, but on them too, and started elaborating laws to fully include these in all areas of social life. When we mention disabilities we do not mention only permanent ones (physical of psychological) , but the temporary ones too. These temporary disabilities can affect our mobility, dexterity, balance,

speech, hearing, sight, force, resistance, memory etc. [45]

15% of the world's population has a disability, shows a study conducted by the World Bank and the World Health Organization. Of the 15%, 5% are children. According to this study, the poorer countries have much more disabled persons than the richer ones [46].

On the other hand, a report called "Global Population Ageing" driven by the United Nations in 2013 [64], shows an unprecedented ageing of Europe's population. They expect that by 2050 the number of children under 15 will be far below the number of persons aged over 60 that will represent over 40% of the entire European population [65].

Taking into consideration the truism that everyone suffers at least once in a lifetime of a certain disability, one has to make sure the places we work in, live in or visit are truly accessible. The demolition of any kind of barriers is European Union's definition of inclusion [47]. Inclusion is desired in order to offer equal opportunities and rights to all the European citizens. This means inclusion must be incorporated into the building sector too.

Therefore, creating environments that can be used by anyone, regardless of sex, age, size or ability is demanded. The building that encompasses all the elements that are crucial to using all the space at maximum of potential and in an efficient manner, without the necessity of personalization for each individual separately is called an inclusive building.

Worldwide, inclusive building is called "building for everyone". This idea aspires to enhance acces in buildings for everyone by outlining: perfectly working entryways, proportioned go through ways and effectively seen and read signs, both in new and existing structures. Inclusive building wishes to be imperceptible for the eye as it desires to evade circumstances in which disabled persons feel ungraceful. The ease in accessing and imperceptible design is given by: non slippery surfaces, elevators between floors, vast passageways, carpet free floors, accessible audio and tactile indicators, fewer or no doors, pebble free alleys, equitably disseminated light inside the rooms etc. [48]

In Europe this concept was named "universal design" and it was created for individuals to be considered primary choice elements when planning a building and for all the factions included in developing a building to begin incorporating everybody's necessities in the ventures they create. This idea respects each need and wishes to build structures so as everyone can utilize and access them as effortlessly and freely as possible, without the need of exceptional adjustments. Universal design incorporates the accompanying attributes: safe and accessible entrances, sufficient lighting of stairs and access routes [50], safe and easy to access routes, parking with elevators, contrasts in level furnished with handrails and guard railings [49], ventilation, handrails on stairs and in elevators [52], well dimensioned properly signaled bathrooms with all the necessary equipment [53], leveled and non-slippery interior surfaces, warnings and signs (audio, visual, tactile), avoid the use of doors [51], accessible furniture and safe evacuation in case of emergencies arise [54].

4.2. Standards and initiatives

On the subject of disability, various strategies emerged. *European Disability Strategy 2010-2020* is a strategy developed by the European Union in order for disabled people to participate to societal life and the economic one in all of their aspects and to break the barriers that block disabled people to exercise their fundamental rights and freedoms through: accessible internal markets for both goods and services, accessibility to public life and recreative activities, social insurance, equality, accessible education, accessible health system etc. [56], [57]

The United Nations endorsed a convention on this topic called *United Nations Convention on the Rights of Persons with Disabilities (UNCRPD)*. This convention validates decades of work are it's based on 8 fundamental principles [59]:

- Respecting the dignity, autonomy, independence and decision making capacity of each individual
- Non-discrimination
- Full participation in societal life
- Regarding disability as a diversity
- Equality of chance
- Equality between men and women
- Supporting and developing disabled children's identities

European disability Forum, a non-governmental organization that helps over 80 million disabled persons drafted a law proposal called *European Accessibility Act* [58]. This proposal desires to incorporate impaired persons in every aspect of economy and society, to make the market of goods and services accessible to disabled persons and to have a homogeneous policy on accessibility.

Americans with Disabilities Act (ADA) [60] is the American Congress's law that bans discriminating on disability grounds and upholds equality in using accommodation, commercial buildings, administrative buildings and services of all kinds.

New Zealand adopted in 2004 *The Construction Law* that stipulated that all public buildings must be accessible in every way [17]. *New Zealand Disability Strategy* is a national strategy that stipulated the basis of abolishing obstacles that interfere in a disabled person's life in order for them to fully participate to their community's life [81]. *China's Regulations on Construction of a Barrier-Free Environment* law passed in 2012 and requires for all new designed or refurbished roads and buildings in the urban area to respect the construction standards that require the building of barrier-free environments, accessible to all. This law does not only refer to public buildings, but to private ones too. Anyhow, China is no stranger to the concept of accessibility, taking into account that in 1990 it passed the *Law on Protection of the Disabled* that required the gradual construction of accessible roads and buildings [82]. In 2010 Australia adopted *Disability (Access to Premises - Buildings) Standards*. This standard facilitated the improvement of access in buildings for disabled persons in order to offer them a chance at employment, education and services [83]. *National Disability Strategy of Ireland* is a strategic plan elaborated after consulting with the disabled persons, their families, their careers, their supporters and the industry in the field. This strategy marches on several domains: transport, government and environment, companies, commerce, employment, construction, energy and natural resources, social protection and children's health [84]. *NS 11001:2009 Universal design of building constructions* is a Norwegian standard that refers to both public and private buildings and regards both the building and the its surrounding environment [87]. *Vietnam National Law on Disability* was created to help disabled persons to actively and productively participate in society, keeping in mind that 15.3% of the population in Vietnam is disabled, 75% of which live in rural areas. This law enforces the construction of accessible buildings and transport system [88].

Another code of practice in constructing accessible buildings is *BS 8300:2009 Design of buildings and their approaches to meet the needs of disabled people. Code of Practice*. This standard applies to all kinds of buildings, starting from public ones to bars, prisons or concert halls [85]. With regards to accessible apartments and individual homes there is a code of practice called *BS 9266:2013 Design of accessible and adaptable general needs housing*. Code of practice [86].

As one can observe, there are numerous standards in this field. As expected, initiatives are even more. *World Association of Persons with Disabilities (WAPD)* is a non-profit international

organization that supports itself on donations and contributions from individuals and companies so as to help the disabled to grow and evolve as individuals through their talents [61].

The European Commission has its own unit that advocates equality and develops policies on behalf of the disabled persons. This unit is called *European Commission's Disability Unit* and is in charge with [56]:

- Facilitating the cooperation between the member states of the European Union in order to develop policies on disability
- Making sure disability is taken into consideration when laws are elaborated
- Raising the awareness on disability and supporting non-governmental organization in the field
- Employment of the disabled at European level

American Association of People with Disabilities (AAPD) [89] is the largest organization in America that encourages and supports disabled persons to live independently and have equal opportunities as all Americans do. They support economic growth and the participation of disabled persons in politics and activate in several fields: construction, health, education, employment, technology, transport etc.

Centre for Accessible Environments (CAE) [62] is a British charitable organization that in the last 40 years is considered to be a leader in inclusive design with respect to accessing a building. It offers information and council to organizations that work in this field. *Livable Housing Australia (LHA)* [63] is a non-profit partnership that unites the Australian community with the industry and the government in order to develop solely inclusive buildings by 2020. In order to achieve this goal, they have developed a guide called *Livable Housing Design Guidelines* on residential buildings. *Centre for Excellence in Universal Design (CEUD)* was created in Ireland and it dedicated its activity to the universal design principle. Its main activities are to: inform, promote and conduct research in the field, standardize the construction industry at national level, develop and maintain good practice in universal design and raise awareness on disability. The list of organizations and initiatives that defend and promote disability are endless, considering every country has its own initiatives and organizations: *Vietnam Federation on Disability (VFD)* in Vietnam, *Conseil français des personnes handicapées pour les questions européennes (CFHE)* in France, *Norwegian Association of Disabled (NAD)* in Norway, *Consiglio Nazionale sulla Disabilità (CND)* in Italy and so on.

4.3. Technologies used in designing inclusive buildings

When designing an inclusive building one has to consider 5 crucial elements: the exterior environment, entrances and horizontal circulation, vertical circulation, the interior environment and sanitary facilities.

With reference to the exterior environment, there are several limitations that appear with respect to space and the natural habitat. Furthermore, when designing accessible exterior environments one has to make sure [49]: parking spaces are large and of adequate number in accordance with the building's use, there have to be designated spaces for "parents with children" as close to the entrance in the building as possible, the way from the parking to the building should be accessible and easy to understand, access ways should have resting spaces, surfaces should be smooth, slip-resistant, firm and wide, changes in level should have handrails and guard railings, well signaled ramps and oscillations of level, waterproof surfaces, stairs should be an alternative to ramps, every step of the stairs should be well lit.

The entrances in a building and in other rooms of the building are extremely important elements

when designing inclusively. In order to have accessible entrances, one has to make sure [50]: the main entrance is visible, universal in design and protected by weather, avoiding lobbies is advised, the reception area should facilitate movement in all ways, have perfect lighting and have signs on where to find everything, the surface in the reception area should be firm and non-slippery and the waiting area should have plenty seating areas, including for wheelchair users. The horizontal circulation in a building is made through rooms, corridors and lobbies. These have to be accessible and logically organized to permit easy navigation in the building. Accessibility, ease and logic in horizontal circulation are given by [50]: avoiding changes in level at the same floor, handrails on walls in corridors, resting places at least every 20 m, wide corridors, avoiding lobbies and doors, accurate lighting in every room etc.

Vertical circulation is the way inhabitants move from floor to floor through lifts, ramps or stairs. The main attribute of vertical circulation is safety. Safety can be achieved when [51]: stairs are well dimensioned, every edge of a stair is signaled accordingly, the entrance and landing of stairs are lit appropriately, stairs should have handrails on both sides and if they are wider than 2000 m an additional handrail on the middle will be build, passenger lifts are preferred to platform ones, see through elevators are not desired, lifts should have handrails, be fire resistant, have audio and visual warnings, have an easily accessed communication system etc.

The interior environment of a building comprises a series of elements like: floors, ceilings, windows, furniture etc. In order for all this elements to be inclusive, we have to make sure [52]: the floor is firm, non-slippery (whether wet or dry), the changes in material on floors should contrast visually, avoid fluffy carpets, the light should be evenly distributed and creating shadows should be avoided, the floors must contrast in color with the walls, electrical cables must not interfere with the portable audio equipment, signs should be audio, visual and tactile, the alarm system should warn visually and audibly etc.

When building inclusive sanitary facilities, the engineers and the designers must know the needs of the inhabitants in order to foresee their demands. In general, inclusive sanitary facilities should be [53]: signaled accordingly to be easily identified, large so as to permit a wheelchair user to turn, equipped with accessible washbasins at different heights, the floor surface should be well drained and dry, walls should have handrails where necessary, water temperature control must be easily accessed and used, have accessible alarm systems etc.

5. The ties that bind: SUSTAINABLE AND INTELLIGENT BUILDINGS

The headway of technology in numerous fields is due to technological evolution. However, this evolution is responsible for the degradation of the relationship individuals have with the entire eco-system. Gore believes it to be a vital and compulsory action to fuse intelligence with sustainability because “old habits + old technology = predictable effects” whereas “old habits + new technology = unpredictable effects” [35]

In some persons’ opinion, extravagance is synonym to intelligence in the construction domain, despite the fact that the most truly believe that sustainability and intelligence go hand in hand and should not exist separately [36]. Specialists, practitioners and researchers in the field of construction gathered in two separate schools of thought. One of the schools considers that intelligent technologies are at the basis of sustainable building [40][41][42][43]. The other school of thought, and the smallest, states that in order to reduce energy consumption one has to use natural solutions, solutions that will furthermore lead to a reduction in money spending [38][39]. The first of these groups states that intelligent control systems have a handful of functions, among which to stop or start equipment that monitors the occupancy degree of a building at a certain moment of the day and the space conditions and therefore, has the ability to substantially reduce the consumption of energy

based on previously set strategies. They also say that the continuous adjustment of ventilation and surveying the air quality can be improved through intelligent systems and that using natural light at a maximum of potential can only be achieved by an automatic blinds system. An intelligent system can optimize the consumption of energy by setting a timetable for each area of the building so that lighting and the HVAC system to start only if there are inhabitants. For this to be made possible, the existence of movement sensors is necessary. Although these sensors have an initial high cost, energy cutbacks will be substantial [95].

We have concluded, after circumspectly examining the existing literature that we are in agreement with the group that braces sustainable intelligent buildings. There are numerous advantages in using intelligent systems when designing sustainable buildings because they will help reduce energy, CO2 emissions, operational costs will reduce significantly, maintenance will be cheaper and the inhabitants will be more productive and they will have a higher degree of comfort.

Nonetheless, researchers in the field recommend giving up on implementing technology centered systems and encourage implementing systems that take into consideration the human factor and that support the interaction between the inhabitant and the space they live in. They believe that in order to develop both sustainable and intelligent buildings, studying and predicting human behavior and intertwining intelligence is desired [44], [96], [97]. Newman and his team of researchers conducted a study that showed that the consumption of energy can be reduced by 10% in an environment system controlled by the inhabitant, compared to a fixed intelligent system [99].
CO2 emissions are expected to reduce by 4 gigatons by 2020, according to SMART 2020, a program that studies intelligence with regard to carbon emissions. Intelligent buildings are believed to be able to reduce the energy consumption by 50-70% and water consumption by 30-50%. [39] The building management system in a building can reduce the consumption of energy by 20-25%, according to one of the most prominent companies in the energy equipment field [55]. According to Clarke, the most substantial energy reductions in a building are directly linked to the management heating/cooling system. He states that by decreasing the temperature in a room by 1˚C, the energy costs will go down 7% [99].

A sustainable intelligent building must be comprised of three components that are always interconnected. These components are: people, products and processes. People are de individuals that own or rent the building. The management of the facilities, the design of the building, its budget and its execution degree are the processes. The materials used in the building, including all equipment and appliances comprise the products element [37].

The benefits a sustainable intelligent building has on the environment and on the inhabitants is undeniable. Whether we mention low consumption of water and energy, decrease in CO2 emissions, higher comfort, safety and security or healthier environment, the assets such a building endeavors are tremendous.

Sustainable buildings and intelligent ones have been observed to have common tendencies. Hence Continental Automated Buildings Association (CABA) proposed a new name for them: bright green buildings [36]. Their convergence can be seen below.

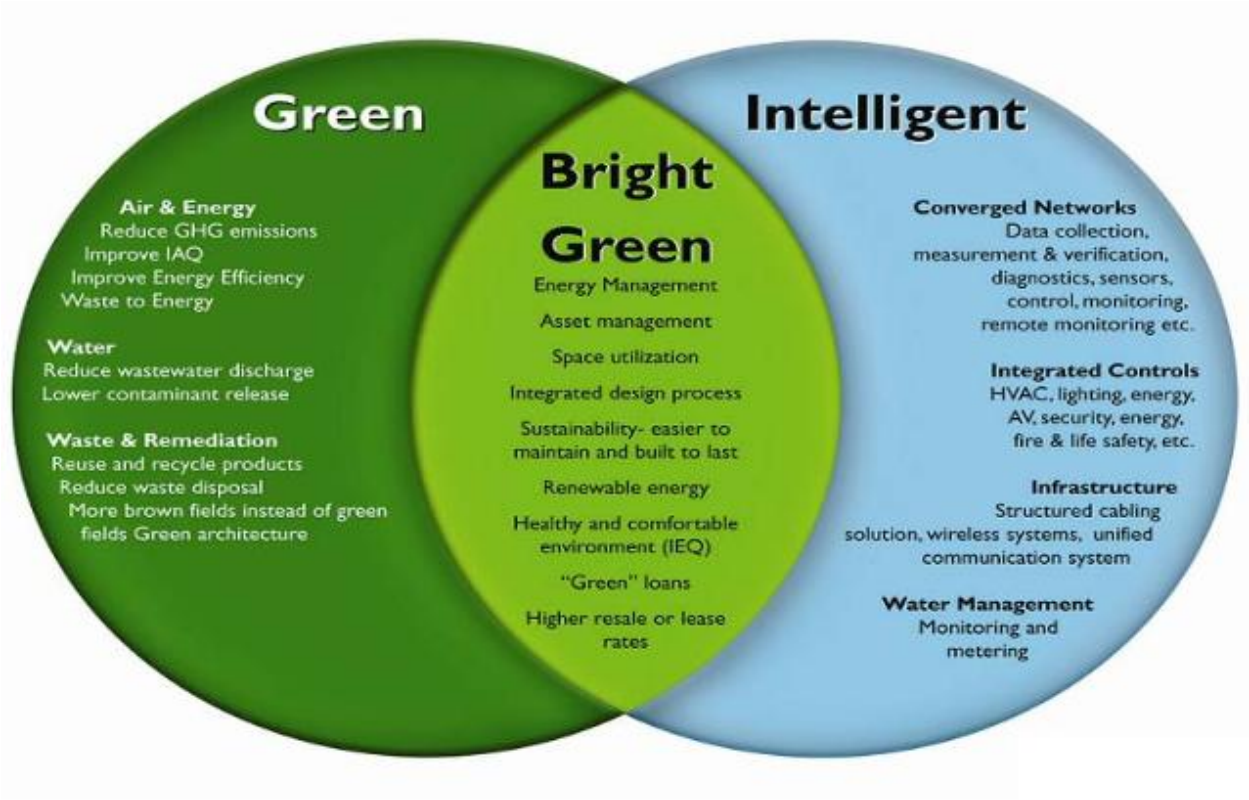

Figure 1. Convergence sustainability + intelligence
(source Frost & Hartman, 2009)

6. The ties that bind: INCLUSIVE AND INTELLIGENT BUILDINGS

While sustainability is a topic used by the majority of designers and builders when taking about intelligence, inclusivity does not seem to be on anyone's mind. In our opinion, inclusion should be a primordial concern for the society we live in, in the century we live in, a century in which, at least in appearance, everyone is concerned with the right to equality among individuals.

Building Research Establishment (BRE) elaborated a research project called Assisted Living Innovation Platform (ALIP) [93]. This program comes to support the elder population and the disabled one by offering them independent living. By using intelligent systems in building and communities, ALIP lays the foundation for effective communication and exchange of information between the industry, professionals from the medical field and patients, modulates services and assisted caring systems for each individual separately and designs interoperable technologies and services accessible to everyone from any location.

A practical example on building intelligent inclusive buildings is the House of Disable People's Organization in Denmark [94]. This building is a promoter in this field as it perfectly combines the two elements. The intelligent systems in this building reduce the energy consumption by 40% while they facilitate the ease of movement, both inside and outside the building for inhabitants and guests.

7. The ties that bind: SUSTAINABLE AND INCLUSIVE BUILDINGS

The evolution of society and its principles in the last years enforced an uncommon and extraordinary trend. This trend ascends the individual, his needs and rights at the same level with environment protection.

US Green Building Council (USGBC) organization, one of the most reputable supporters of

sustainability, is the first to include in its principles social equity, starting with the 2013-2015 Strategic Plan [91]. To achieve this target, USGBC advises designers, engineers and beneficiaries to build more accessible, healthier, more qualitative buildings that protect the environment. In supporting this principle USBGC offers LEED credits to the projects that take into consideration the needs of everyone when designing a building, starting from the designing stage and ending with inhabiting the building. These credits are believed to mature the buildings' market leading to sustainable accessible constructions.

The Institute for the Built Environment developed a measurement tool to help designers and constructors incorporate the human factor in developing sustainable buildings. This instrument is called LENSES [92] (Living Environments in Natural, Social, and Economic Systems) and comprises 3 revolving circles that show the correlations between each element and their interrelations [91].

Although at an incipient stage, the incorporation of inclusive characteristics into sustainable buildings will gain momentum as the benefits are tremendous, for both the individual and the environment.

8. Conclusions

On Earth today there are 7 billion people and population is relied upon to achieve 8-10 billion by 2030. Urban population measures 50% of the total population and it is considered that by 2030 it will outweigh rural population by 2.1% [101]. Contemplating the development rate is exceptional and resources are constrained, the common inclination to ensure the resources and the habitat, without underestimating or disregarding human rights, happened.

In the construction domain, as did in all fields and industries, there appeared a leniency to sustainability. Specialists in construction agree upon the fact that sustainability is the only way to protect resources as wood, water, energy while being extra careful about the environment. Other than being proficient from the resources' perspective, these structures are halfway or completely competent to manage themselves while avoiding endangering the health of the inhabitants.

It is believed that a regular person spends up to 90% of his time in a building. Subsequently, it is critical and imperative for a building to offer an environment that promptly responds to the needs of the occupants and is solid, protected, protective, comfortable and adaptable. These prerequisites are satisfied by the intelligent building while it manages resources efficiently with the help of intelligent systems and technologies. An intelligent building satisfies all these and moreover deals with the proficient utilization of assets.

The new struggle on human rights led the construction sector to innovation. Although at dawn, the construction of inclusive buildings is expected to rise incommensurably, considering the fact that everyone, despite age, sex, race, size, ability or disability, has the right to free access and the right to fully participate in society. The construction of inclusive buildings facilitates and supports fundamental rights.

Lately, an intelligent building is imperative to be sustainable. The imperative comes from the benefits arisen from the fusion of: low consumption of resources, environmental protection, higher safety, higher security, increased comfort all with the help of innovative technologies.

The characteristics of an intelligent inclusive building are the security systems, the access system, the lighting system and the communication systems. In our opinion intelligence must be incorporated into inclusive buildings because true accessibility cannot be reached in a society

without technology.

We believe that humans and the environment are both equally important factors in the survival of our planet. One of the first steps in fulfilling the ideal of protecting both will be the development of inclusive sustainable buildings. The mutual concern for the environment, whether interior or exterior, in inclusive buildings and in sustainable ones, will be the tie that will determine the industry towards constructing inclusive sustainable buildings.

Starting from the basis set by the European Union in their strategy called Europe2020 – A strategy for smart, sustainable and inclusive growth and continuing, the AGE Platform Europe created a manifest for constructing buildings (both public and private) for Europeans that incorporate all the three characteristics [102].

In the existent literature and practice in the construction domain, except from the initiative mentioned above, there is no mention of the concept of developing sustainable, intelligent and inclusive buildings.

Design innovation is the key to conceptualizing and developing these futuristic buildings.

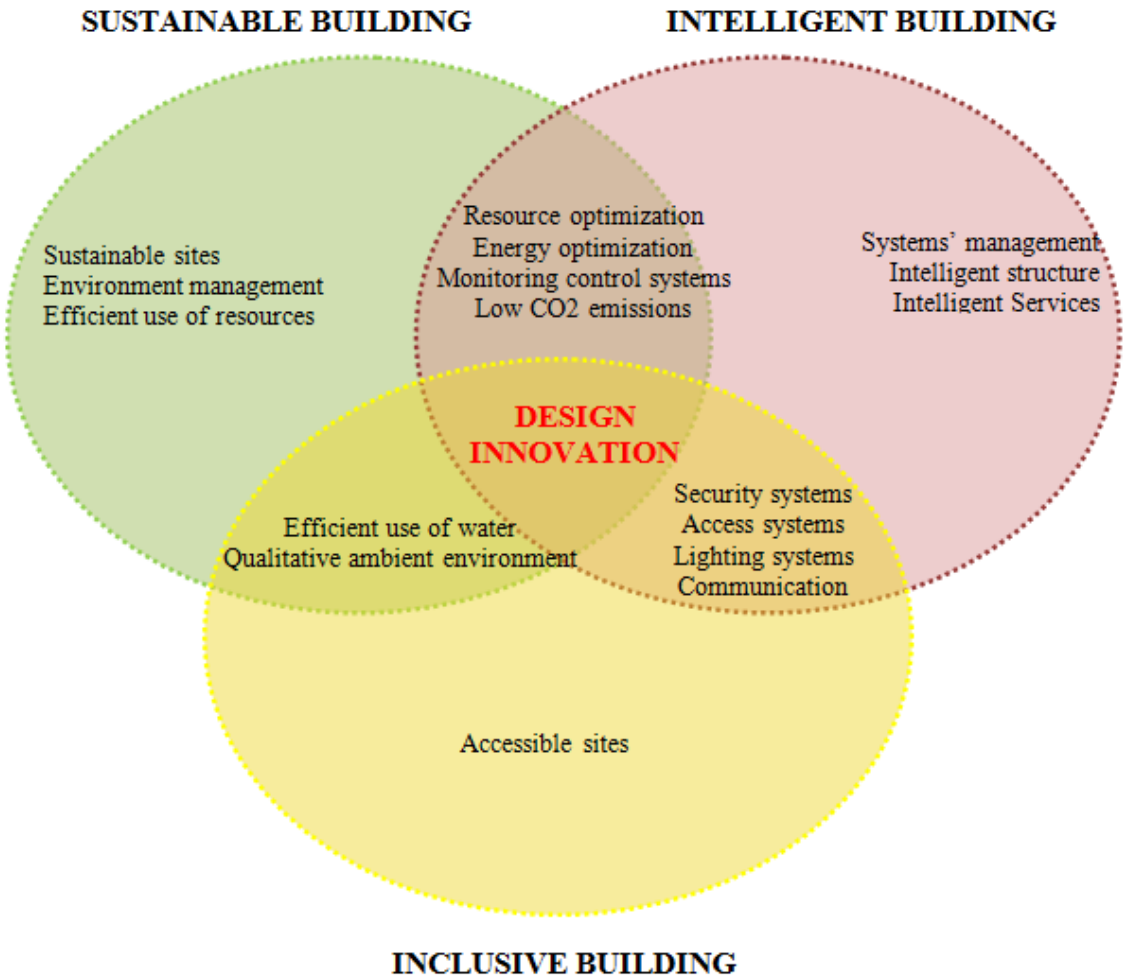

Figure 2. Sustainable Intelligent Inclusive Buildings

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