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Smart and Intelligent Buildings Achieving Architectural Concepts

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Abstract : **:** In dealing with the building to scrutinize core idea and architects' perceptions and concepts of "Intelligence" vs "smart", with existing theories, to identify possible prospects and opportunities. Through the findings and analysis, the paper aims to provide an applicable guide for architects working in different buildings contexts, to consider for buildings termed "Intelligent" above "Smarter". Various theories and learning points arising from the research in their formulation and implementation of "smart" and "intelligent"

The goal of this paper is to assess how are architects - conceptualizing an "Intelligent building" vs "smart building"? Are architects' perceptions and concepts of "Intelligent building" and "smart buildings" clear with existing schemes of "Intelligence" and "smartness"?

Various experts of intelligent building components have emphasized that the technological aspect of an intelligent building is composed of operations that can be divided into four major categories: Energy Efficiency, Telecommunication systems, Workplace Automation, Life safety systems, is this true?

Keywords: Intelligence, Intelligent Buildings, Intelligent Architecture, Passive Intelligence, Active Intelligence

1. Introduction

Contributions from new types of science shall link disciplines, knowledge systems and societal partners to provision a quick global innovation system for people to prosper in a sustainable and equitable world taking the world to The vision of Future Earth.

Bergsen his central point was "Human beings do not only use current tools, but also create tools using their intelligence" [(1)]

Concentrating on three Research Themes – Dynamic Planet, Global Sustainable Development and Transformations towards Sustainability; the scientists will focus to develop the knowledge to support decision-makers at all scales and in various frameworks.

Few terminologies are addressed as sustainability, energy efficiency, Energy saving programs, smart.

"It is today that we create the world of the future" Eleanor Roosevelt - 1945 [(2)]

Where design process can be done in automation flow and it takes a short time to create number of design options. A software that would be able to produce multiple design options and suggest 5 best options among them in express way for consultant to consider.

An efficient and effective collaboration platform for all consultants that enables them to work in real time with a stable connection.

The seven forms of t human intelligence thought of by Gardner results in Building intelligence:

"Logical-mathematical, musical, linguistic, interpersonal, intrapersonal, visual-spatial and bodily-kinaesthetic."

We shape our buildings; thereafter they shape us - Winston Churchill, year 1943.

Buildings are alive. They talk and breathe". They have the intelligence to sense and react, anticipate and illuminate. Buildings are inherently connected to their usage and surroundings and therefore their indoor environment is the result of a range of interactivity affected by daily and seasonal

changes in climate; and by the requirements of occupants changeable in time and space. Over the period of time the world prefers use of technology where building will be more productive; operationally efficient for the owners and ecofriendly [(1)]

1.1. Problem definition

Defining the Intelligent building and identify the design Criteria for Architects information.

There is no universal definition for the intelligent building perception, although a certain consent about the concept is found. There is little experiential evidence about the factors or the feasibility of; involved in any intelligent building and there is no narrative of the intelligence of buildings.

The actual query within the intelligent building concept paradigm was the problem of the intelligent building concepts describing the intelligent building, not the building intelligence.

Constant transformational processes brought by data-driven applications which posture new challenges to the society making Data is the driver of the new era, and it is growing. These challenges are imbedded in the human nature and aren't in the technical field of AI development. Whereas 35% of the skills required for jobs across industries will change by 2020, at least 25% of the workers in some countries is already reporting a skill discrepancy versus to the skills demanded by their current jobs (WEF, 2017). The problem is in skills requirements of the new jobs (MIT Sloan Management Review, 2017; WEF, 2018) that are being created today; not the absence of jobs.

Many questions which need clear answers to Architects to capitalize on the use of intelligence in buildings should be clarified in this thesis; to enlighten the choice for buildings components to address the building stakeholders' needs examples are:

How are architects - conceptualizing an "Intelligent building" vs "smart building"?

Are architects' perceptions and concepts of "Intelligent building" and "smart buildings" clear with existing schemes of "Intelligence" and "smartness"?

1.2. Main goal

To provide an applicable guide for architects working in different buildings contexts, to consider for buildings termed "Intelligent" above "Smarter". Various theories and learning points arising from the research in their formulation and implementation of "Smart" and "Intelligent"

12.1 Research methodology

Analytics research will be used as a research methodology to investigate

The difference between Intelligent and Smart building based on the design criteria for each, and the risks associated with them.

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Designers should have the upper hand in the building performance throughout its lifetime, starting from the project location and passing through the factors to be considered conserving the energy consumption.

In a research by Sherbini & Krawczyk (2017), they focused on the concept of intelligent architecture started as an interest in the latest integrated building systems operating a single building or facility, so that systems can communicate and exchange information. [(3)]

In another research by A.H Buckman et al. (2014) and M. Mayfield et al. (2014), they focused on the lack of clarity between Smart and Intelligence as a definition and started analyzing the terminology.

Khashaba, et al. (2014) in his research "The use of intelligent buildings to achieve sustainability through an architectural proposal for public buildings in Cairo" was stressing on the prominence of exploiting the intelligent applications in all the public buildings in Egypt and how the paybacks can be measured emotionally and economically.

An intelligent building can be defined as "the building that combines the best available concepts, designs, materials, systems and technologies in order to provide an interactive, adaptive, responsive, integrated and dynamic, intelligent environment for achieving the occupants' objectives over the full life span of the building." [(4)]

Aschehoug et al. (2014) Much interest has recently focused on intelligent envelopes and facades by adaptive or responsive actions which should make it possible to optimize the maximum of this energy for building purposes and facilities. [(5)]

1.3. Architectural Design Process Upgraded

By the 1980s, the number of factors to be considered during the design process had increased, and because of their interactions, structures became more complicated. The tasks were no longer possible to solve by applying traditional methods, therefore deliberate design methods have taken shape and spreaded. To answer changes of the weather, all the structure of interior spaces, the shape and the constructions of the building have to be optimized. It is a proven fact that the majority of the energy a building needs can be saved by only applying architectural solutions. [(6)]

Without intelligent architecture, buildings will not be able to perform intelligently no matter how complex the electronic gadget built into them. Intelligent architecture is therefore the passive intelligence while the computerized electronic systems are the active intelligence of the building. And the higher the passive intelligence in a building, the higher the active intelligence the building can accommodate. The new role of the architects is therefore to learn more the science and the art of putting intelligence into building designs. [6]

1.4 The Intelligence New Project Team Structure

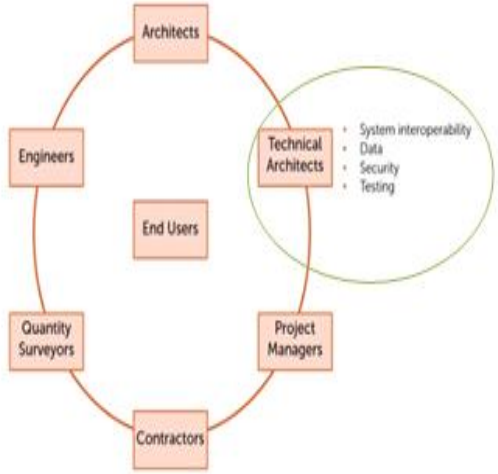


Fig (1) New Project team Structure

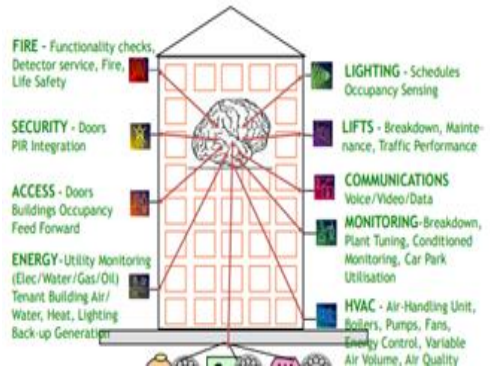


Fig (2) The Smart Building Services

2.1 SMART DEFINITION

Smart is an adjective that classifies the intelligence of a person. Yet, when we compare the two adjectives intelligent and smart crosswise, **smart may indicate a lower level of intelligence.** [7]

Smart architecture maybe comprehensively defined as a mixture of passive and active technological and architectural strategies that connect computationally networked, globally connected, complex-adaptive and real-time responsiveness in order to form a co-evolutionary entire with the inhabitants. [8]

Smart systems are subdivision of Intelligent Buildings, this is an academic opinion (Kaklauskas et al., 2010; Clements-Croome, 2011). By personalizing intelligence as the ability for a building to collect information and respond to it, there is currently the opportunity to minimize the addition of sub sections to intelligence definitions and consent advanced research into future building design. [9]

Smart or clever buildings, concentrate on control systems, but intelligent buildings go deeper than this. An intelligent building effectively grows with changing user requirements and technology through implied reasoning, to ensure continuous and enhanced intelligent operation, maintenance and optimization. The key attributes of environmental sustainability are revealed to value present and future generations.

2.2 SMART BUILDING SYSTEMS CHART

Table(1) *The Smart Building Chart*

Aspects	Process	Target
Connecting building systems	The planning infrastructure	Health and wellbeing
Connecting people and technology	The information infrastructure	Productivity Leakage
Connecting to the bottom line	The service infrastructure	Avoid noise and temperature extremes
Connecting to the global environment		Comfort and satisfaction.
Connecting to the smart power grid		Lower the costs of equipment installation, operations, and service
Connecting to an intelligent future		Improve building performance, including energy, operations, security, and comfort
		Generate significantly higher user satisfaction rates

3. The Definitions of Intelligent Buildings

Intelligence is something with which you are born.

Based on Cattell's theory (1963, 1987); intelligence is characterized by two main concepts General fluid intelligence and General crystallized intelligence, Fluid intelligence consist of skills as memory, learning potential, etc. which are not taught or learned through education. The crystallized intelligence is validated through the ability to think in a logical way using concepts learned and the accumulated knowledge and the ability to think in a logical way using concepts learned.

If we compare the two concepts meaning; intelligence depends on the accumulated knowledge, learning potential and the cultural influences. **(10)**

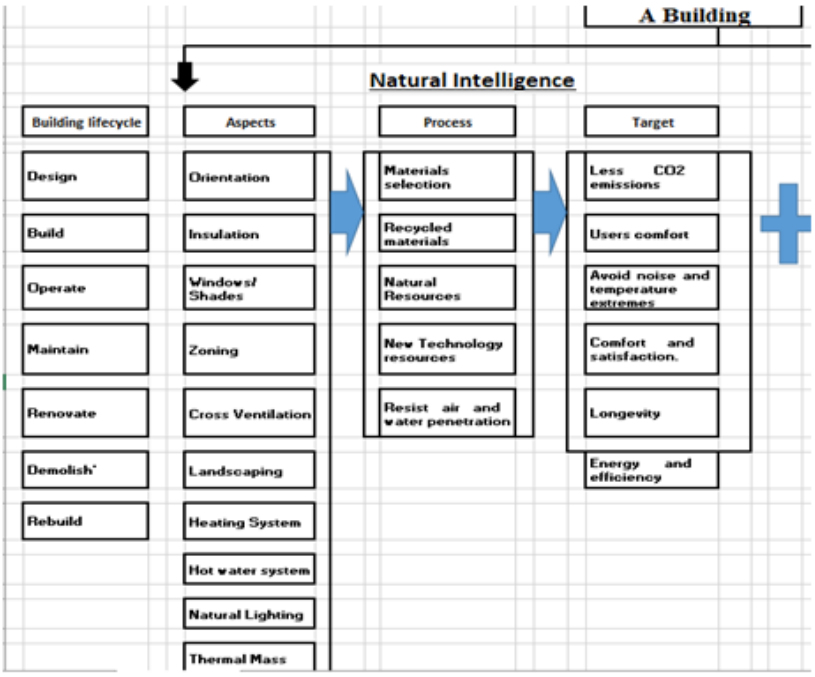
"A building which totally controls its own environment" (Stubbings, 1988). This seem to infer that the technical control of all building systems operations; which is very important –naturally given to a management computer system. Such interpretation does not propose in Intelligent Building the user interaction at all (Powell, 1990). **(11)**

3.1 Building Intelligence is Natural Intelligence + Artificial Intelligence

We build Buildings for many reasons, cooperation, permitting inhabitants to be efficient, creative and productive. Intelligent buildings deliver interaction, cooperation and improved occupant circulation. From the design perspective the study starts from how the occupants will enter the space and circulate through the building? How will they transport in an effective way inside the space vertically and horizontally? Should a digital signage be incorporated to improve circulation and navigation?

Through the use of design elements, cooperation also can be improved encouraging networking in formal (conference rooms, break rooms, classrooms, and seminar rooms) and informal spaces (niches; and seating spaces in corridors, coffee shops, outdoor seating, and others) where building occupants can gather for planned or unplanned interactions. **(12)**

Table (2) The Intelligent Building Chart



3.2 Major Difference between A Smart Building and An Intelligent Building

The key difference between a smart building and an intelligent building is: an intelligent building is able to analyze data from multiple sources. The building facility assets control becomes 'intelligent' when it evidences the facility's capability to acquire from the gathered data and adjust operations accordingly. (12)

You need to work in order to become smart as it is an earned status whereas intelligence is something that you have been fortunate enough to gain from your parents. There have been many different tests proving that 75% of the intelligence of a child is actually inherited from the parents. This also justifies that intelligence is inherited and not developed over time as the status of smart is. **(13)**

3.3. Intelligent Architecture

In most cases, people often confuse intelligent buildings with high-tech buildings. According to Pantelis. (2002), this is totally wrong. An intelligent building is not gadget-oriented. It must be designed to suit the present and future needs of the occupants. It must easily and economically accommodate changes, have its basic elements integrated as part of a synergetic whole, and above all, cost effective. In real, an intelligent building reflects the knowledge and the intelligence of the designers or planners According to Bjorkdah. (1999), you cannot change a building to be intelligent, it has to be designed "intelligent" from the first draft and make all the studies necessary for that. When start designing an intelligent building as it is not only the building itself and the systems installed into it, also the technical systems must be considered. Intelligent architecture therefore precedes intelligent building. It prepares the ground for intelligent building. The higher the passive intelligence, the higher the active intelligence the building can accommodate.

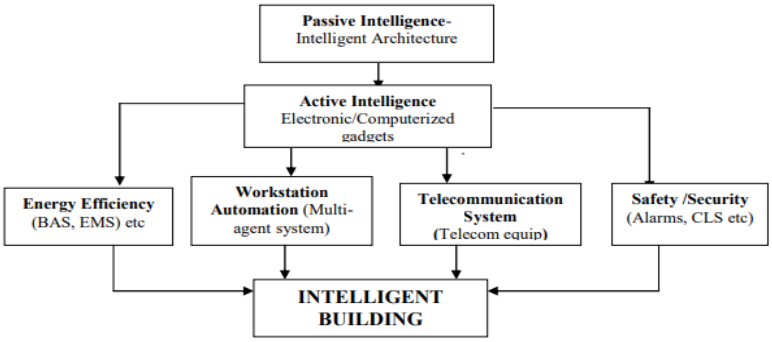


Fig (3) Sequence of Achieving Intelligent Buildings

4.1. Risks Associated with Smart Buildings

Smart buildings are activated section by section/floor by floor, with different companies using different systems without communicating with each other. Each provider will have separate controls, cabling and security standards which naturally generates vulnerabilities. No system is fool proof of course, but a highly encrypted and certified network can significantly minimize the risks

4.2. Risks Associated with Intelligent Buildings

1. Conciliation of open and standardized operating software.
2. Conciliation of the management level and automation level Ethernets via physical network wiretapping.
3. Automation level software conciliation, such as LonWorks and BACnet.
4. Addition of a foreign Workstation and/or Controller into the network (i.e., “rogue” device).
5. Implanted system memory and functionality modification.
6. Open and standardized operating software conciliation.
7. Practice of a locally linked but foreign Service Tool or Handheld Programmer.
8. Absence of robust Controller attachments.
9. Conciliation of any form of anti-tamper function.
10. Defeat of power supply.
11. Physical access to the Workstation and its operating software, comprising the management level.
12. External access and conciliation of wireless networks in the IB. [(14)]

4.3. Technology Assessment

To evaluate the status of the implemented systems, the occupant and technical teams may need to start **a technology assessment** for each facility as below:

- Your occupants’ business goals
- The building’s goals developed based on the business goals
- A technology roadmap - Long-term planning and budgeting
- Environmental design support, site pre-planning
- Cooperation with construction design team
- IPD as Smart construction management options
- IOT, Technology innovation to leverage Big Data
- First occupancy and commissioning
- Skill study for Service and maintenance
- Permanent commissioning/FDD/analytics
- De-commissioning especially for the environmental impact [(15)]

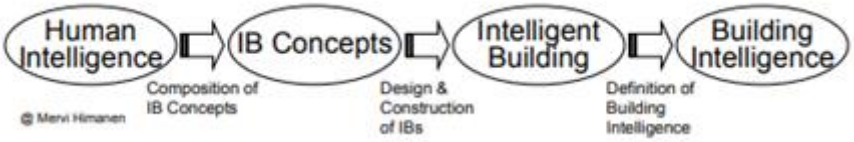


Fig (4) Transformation of Human Intelligence into Building Intelligence

4.3. Factors affecting to intelligent building

Table (3) The Factors affecting to intelligent building

Snr.	***CONSTRUCTION PLANNING***	***Snr.***	*ENVIRONEMENTAL MANAGEMENT*
1	*Sourcing local construction materials*	*1*	*Optimum use of day light*
2	*Efficient use of water*	*2*	*Maintaining air quality*
3	*Efficient landscape*	*3*	*Natural air*
4	*Materials :bricks, glass, aluminum, etc.*	*4*	*Installation of air handling unit*
		5	*Use of LED and CFL lighting*
Snr	***Water Management***	***Snr***	*Waste Management*
1	*Rain water harvesting*	*1*	*Solid waste control Strategies*
2	*Water efficient plumbing and fixtures*	*2*	*Ingress protection n:preventing dust and external elements from entering building*
3	*Water treatment, Recycling and disposal*	*3*	*Separation of non Bio-degradable disposables*
		4	*Grey water handling*
Snr	***Intelligent Building Aspects***	***Snr***	*Integrating Building Management*
1	*Energy efficient building services*	*1*	*Energy Management*
2	*Information Management*	*2*	*Alarm Monitoring*
3	*Building Automation System*	*3*	*HVAC System*
4	*System Integration*	*4*	*Lighting Control*
5	*Communication Wiring, System and Network*	*5*	*Lift Management*
6	*Facility Management*		
7	*Intelligent Building Technology and Design*		

5.1. Zeb Pilot House (Modern Intelligent Building Approach

This residence's design was planned for the 'multi-comfort' standards beyond the current building codes demands for the energy use, acoustic and warmth, air permeability, indoor air quality and daylight factoring**.** [(16)]

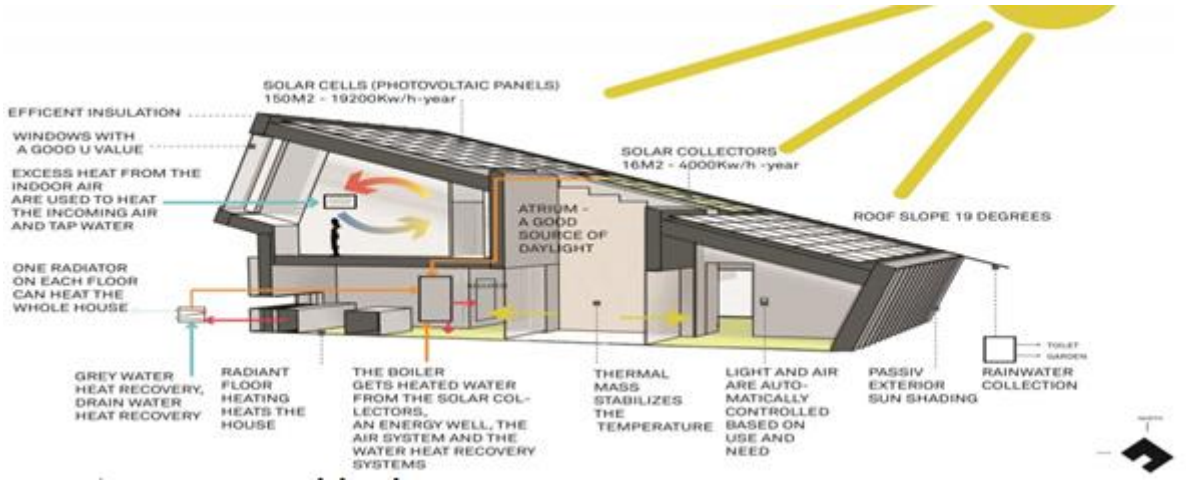


Fig (5) Site Layout and details

5.2. Capital tower, Singapore (Modern Smart Building Approach)

The Capital Tower has a number of smart energy efficiency systems built in, this includes an energy recapture wheel system in the air-conditioning unit, allowing the cool air for recovery. The chillers' efficiency is maintained by this. In the lift lobby and toilets motion detectors installed preserving the energy, using the double-glazed glass windows shall reduce heat dissemination and energy consumption. [17]

6.1. Energy strategies in intelligent buildings:

- Using energy only when really required.
- Use only the amount of energy that is actually required.
- Intelligent systems control heat loss in winter and heat gain in summer.
- Intelligent systems shut down sources of energy consumption in spaces, such as lighting systems, air conditioning and other systems, in case of empty spaces, except emergency corridors and exits escape.
- Intelligent systems can response to the environmental changes outdoor and indoor in order to decreasing the energy consumption.
- Intelligent Systems can use natural light and outdoor air movement and changes of external temperatures to reduce the use of electrical and mechanical systems to reduce energy consumption.
- Intelligent systems can save a part of the energy needed for the building through generating energy from renewable energy systems and integrating it into the total energy required for the building.
- Appropriate Shading devices should secure efficient daylight penetration.
- Reduction of the electricity consumption and cost can be applied using efficient appliances
- Passive heating and cooling through the building envelope.
- Building Energy Management and Control. [18]

6.2. Threats and Obstacles to Apply the Scheme

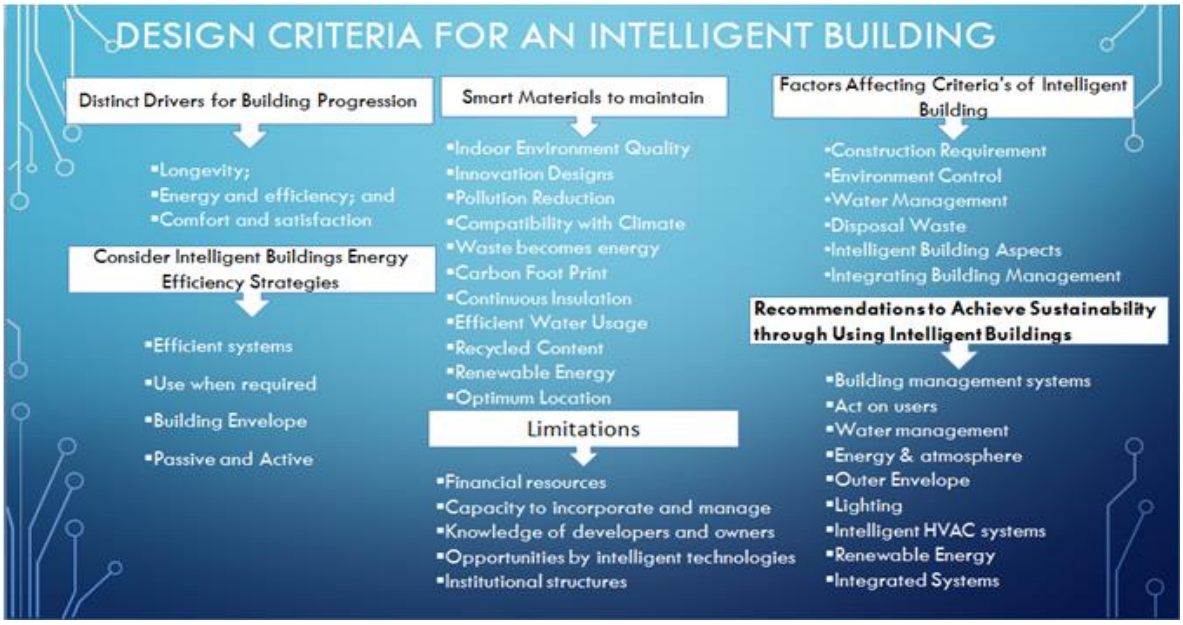
- Lack of awareness for decision-makers of the importance of sustainability for public buildings.
- The lack of specialists who are familiar with the advantages of intelligent buildings and sustainability of buildings.
- The lack of availability of intelligent buildings technologies locally.
- The absence of legislation needed to implement the sustainability of public buildings.
- Lack of funding required modifying existing public buildings so as to comply with the requirements of sustainability by using the intelligent buildings technologies.
- Most of local codes & standards do not take into consideration the sustainability factors.
- The initial cost of using renewable energy, implementing of sustainability and installing of intelligent buildings systems is considered fairly high.

6.3. Limitations

- Commencing with new and 'untested' technologies requires financial resources and confidence
- To integrate and manage intelligent technologies; professional capacity is a must.
- Developers and owners lack of knowledge on the environmental impact in inefficient buildings.
- Intelligent technologies present information on prospects.
- Institutional and establishments structures to boost commitment of such technologies and support till implementation.

6.4. Results

Design Criteria for an Intelligent Building



7. Conclusion and Recommendations

7.1. Conclusion

- The intelligent building is undoubtedly the building of the future.
- Very early planning in the design stage supports the goal of an intelligent building and remains all the way through the building lifetime.
- In several ways, IB reflects the fulfillment of so many LEED or green projects, using the technology to offer a comfortable space.
- The new technologies should always consider the building futuristic approach, should be also flexible, for adaptation and updates to maintain the building functions and benefits.
- The users should have more contribution and feedback to the designers in the building functions required for their comfort and functionality, ongoing process and it should be measured every few years for improvement.
- The new buildings will have different projects team = roles and team structure for the achievement of stakeholders' requirements.
- Risks associated with the intelligent buildings have to be triggered and safe guarded by professionals.
- The smart buildings are fitted out with sensors and accessories, which could be added at anytime during the building span even after they are built.
- Smart buildings are useful and user friendly, but intelligent buildings are powerful and future visionary.
- The intelligent buildings must be born intelligent it cannot alter into intelligence like the smart buildings.
- The future jobs will differ and many jobs will be obsolete and replaced by the new technologies,
- The building intelligence will be the base for the future and specialized firms will evaluate the IQ, sustainability is necessary for any building and will lead into continuity.

- Owners' education about the building intelligence will end with spread of the ideas and success for the futuristic approaches. World will change and people thinking will do the same and follow the modernization.
- Consultants and specialists' technological education and knowledge will guarantee the intelligent buildings future success and improvements throughout the building life span.
- With appropriate marketing, those buildings will induce tenants to sign on with a much greater ease.
- Quantify these benefits, educate owners and consultants, the result will deliver a higher product to the market.

7.2. Recommendations

1. Designers should improve their technological basic ideas and structure a proper project team with certain requirements and knowledge who will work together to end up with a building achieving the key concepts for intelligence and user satisfaction.
2. Colleges should start spreading the sections of study to create more technology particulars for the invention and future way of thinking.
3. Confirm with the owners' obligation to provide a confirmation prove that the building achieves the terms of sustainability and future intelligence and to be a condition for the approval of the permits.
4. Activating the role of research centers and universities in the field of intelligent buildings to achieve sustainability and the future approach.
5. Assessing existing projects and making the required modifications to achieve the aspects of sustainability for these buildings.
6. Improving the users' awareness of the intelligent buildings and the design basic needs.
7. Increase the educational interest in the fields of sustainability and intelligence for all the stakeholders and its stress on importance.
8. Based on the evolving continuous technological progress intelligent buildings have a positive impact on the environment, people and economy, and can be part of further exploration
9. Smart features could fail at any point; intelligence could not fail due to independence.
10. Linking the future technologies and flexible programming features are built in each standalone system for intelligent buildings to act as brained interaction integrated system, smart buildings are reactive, intelligent buildings are active.

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