Dubai Smart Building Assessment System

نظام دبي لتقييم المباني الذكية

by

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Dr. Alaa Abdul-Ameer **Prof. Bassam Abu Hijleh**

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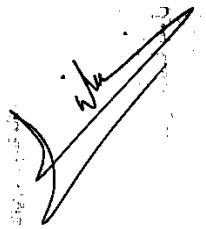

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Abstract

Guidelines and ranking criteria are very important to evaluate buildings. In order to evaluate and define a building as a smart building there should be a criteria or guideline base. In other words an assessment checklist for the building systems, which could be automated to evaluate major building systems, e.g. (HVAC, lighting, Security, etc..). This study is based on the author's self-logical thinking and analytical research on the essence of implementing a Smart Building in Dubai. The target is to establish smart building implementation guidelines or " general criteria " in order to consider a building "smart". Furthermore, it is based on a Smart Buildings (SB) Survey with more than 100 participants including (building owners, Smart Building Systems Vendors, Consultant's Companies and Government Experts) in the Emirates of Dubai. Until now no guidelines or standards were issued on smart systems that should be implemented in the buildings of Dubai. There is no specified framework, code, regulations or even simple guidelines for smart buildings for Dubai's future buildings vision. Although some private companies do their own research on smart buildings score. There are very limited studies about the minimum requirements for implementing smart building procedures. The feasibility and factors conducted in any smart building and the smart building systems which should be implemented, to consider the building smart. Consequently, there is no smart buildings' checklist or clear assessment system in Dubai depending on the different buildings types and usages that are being permitted, in Dubai Municipality. The SB Survey was carried out with the support of Dubai Municipality in 2016, in order to study the feasibility of providing a smart building guideline.

خلاصة البحث

المقاييس والمعايير المحددة مهمة جدا لتقييم أي مبنى من جميع النواحي، للآن لم يتم إصدار أية مقاييس أو معايير ثابتة ومعتمدة في إمارة دبي للأنظمة اللازم تطبيقها في المبنى ليتم تقييم المبنى كمبنى ذكي، من مختلف الأنظمة المستخدمة في المبنى التي بالإمكان اتمتها والتحكم بها بشكل ذكي مثل التكييف والإضاءة والمراقبة والحماية وأنظمة إدارة المبنى وغيرها الكثير من الأنظمة مما يمكن تطبيقها.

هذه الدراسة تعتمد على التحليل المنطقي والعلمي لتفكير الكاتب بجوهر معايير ومقاييس المباني الذكية في إمارة دبي، بهدف وضع نظام تقييم للمباني الذكية "دليل مقاييس محددة" يتم فيه تحديد ما إذا سيتم اعتبار المبنى ذكي أم لا بناء على بعض المعايير والأنظمة التي تم توفيرها فيه، بالإضافة الى أن هذه الدراسة تعتمد على استبيان تم طرحه على أكثر من 100 مشارك من (المختصين في مجال المباني الذكية وبعض ملاك مثل هذه المباني وخبراء المعايير في حكومة دبي) في إمارة دبي، تم القيام بالاستبيان بعد أن تم إطلاق وإصدار الرؤية الجديدة لحكومة دبي (لتكون دبي المدينة الأذكى بحلول عام 2020)، وبناء على هذه الرؤية على المباني الجديدة أن تكون ذكية بشكل إلزامي في المستقبل القريب.

لا يوجد حتى الآن معايير محددة أو أية اشتراطات أو نظام تقييم خاص بمحددات المباني الذكية تم إطلاقه بشكل رسمي في إمارة دبي، بالرغم من قيام بعض الشركات في القطاع الخاص بدراسات وبحوث خاصة بها لتحديد آلية لتقييم المباني الذكية، هناك عدد محدود جدا بخصوص متطلبات ومعايير والانظمة الواجب توفيرها في المبنى لكي يتم اعتباره مبنى ذكي وخاصة في إمارة دبي بالتحديد، وأيضا لا يوجد قائمة تدقيق محددة خاصة بالمباني الذكية بحسب أنواع المباني التي يتم ترخيصها في بلدية دبي، وقد تم انجاز الاستبيان الخاص بالمباني الذكية بالتعاون والدعم من قبل بلدية دبي في نهاية عام 2016. للتمكن من دراسة احتمالية تزويد المباني الذكية بالمعايير الخاصة ومجالات تطبيقها.

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I am grateful to the British University in Dubai for the opportunity to complete my Master Degree.

Finally, a special thanks to my Family for their love, support and confidence in me.

To all above, I will always appreciate all your support.

Dedication

This dissertation devoted, with love, to my Husband **Eng. Mahmoud Al Saadi**, to my parents, my father **Mr.Tareq Al Masri** and my mother **Mrs. Muna Yassin**, who have been the source of my strength and motivation throughout my life.

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AI	Artificial Intelligence
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
APIGBAC	Asia Pacific Intelligent Green Building Alliance Conference
BAS	Building Automation System
BMS	Building Management System
DALI	Digital Addressable Lighting Intelligence
FM	Facility Management
HVAC	Heating, Ventilating and Air Conditioning
ICT	Information & Communication Technologies
IOT	Internet of Things
SB	Smart Buildings
SBSs	Smart Building Systems
SBMS	Smart Building Management System
SBIF	Smart Buildings Implementation Framework
TIBA	Taiwan Intelligent Buildings Association

Chapter One

Introduction

1.1. Introduction

Following the Smart Building Survey, the author of this study completed the analysis of the results and data of the Survey. Recent scientific studies and during the study a deeper understanding of the core of smart building issues were obtained. A comparison between two different large Smart Building Systems, in order to analyse the building classification for each vendor was made. This study is a summary of the results of scientific studies based on SB survey data. A parameters, criteria of assessment system and an implementation plan for smart buildings; gives on indication of the importance of smart building criteria from the building owner, consultants, contractors, governmental entities and vendors. The results marked the importance of having clear criteria and guidelines for smart buildings in Dubai. In general, the opinions of specialists and owners were clearly addressed. The most important requirements for each building type and usage has been sought from among a large number of smart building systems. The study concludes the main smart building system elements in terms of connectivity, smart control and integration.

Consequently, the selected dissertation research subject is -Dubai Smart Building Guidelines- The research includes a detailed study and analysis of guidelines and the frameworks used in a Dubai Smart City. Specifically, building system study in intelligence of new buildings with guidelines and frame work applicable to Dubai's Buildings and projects will be included.

According to Dubai Plan 2021 and Dubai Municipality vision to develop a smart, happy and sustainable city, the first step towards this vision was issuing "Green Building rules and regulations" in March, 2014, with BIM circular to achieve Dubai's vision.

Cities have many elements such as people, mobility, infrastructure, transport, economy, education and buildings which are the major elements in the city. In order to "go ahead"; Dubai's vision to be a smart and happy city, buildings should be "Intelligent".

Analysing and exploring this study will be through a literature review, aspects of smart buildings and exploring the experience of some cities which are considered to be the smartest cities in the world, and conducting some interviews meetings large firms that already issued guidance.

The same path that green buildings and sustainability which Dubai have explored, it is now going ahead towards the smartest city with the smartest buildings. There are some mandatory standards that should be applied for each building in Dubai in order to be Green and there should be a study to specify which guidelines, standards, rules and regulations could be applied. As an author who is an employee working on this pioneer project setting standards, indicators and smart outlines which match and suit Dubai City as one of the most developed and modern cities in the world is important. Also some analysis will be conducted on the current situation. The barriers in Dubai, the development of standards and indicators will be necessary. In addition to analysing the implementation method and phases, a detailed overview on best practices on the best smart buildings according to IESE and smart Cities Index in accordance to the smart cities council will be considered.

In particular, what is the general framework outline to implement DUBAI SMART Buildings? And what are the main challenges enabling this vision to be reached by 2020?

1.2. Research Background

The winner of the world's "smartest" cities, for the year 2015, was taken by consedring New York, London and Paris, respectively. According to the IESE Cities in Motion Index (ICIM) shown below, New York takes first place in technology, governance and economy. Dubai compared to Abu Dhabi and New York, is still behind regarding the technology index as indicated in diagrams below.

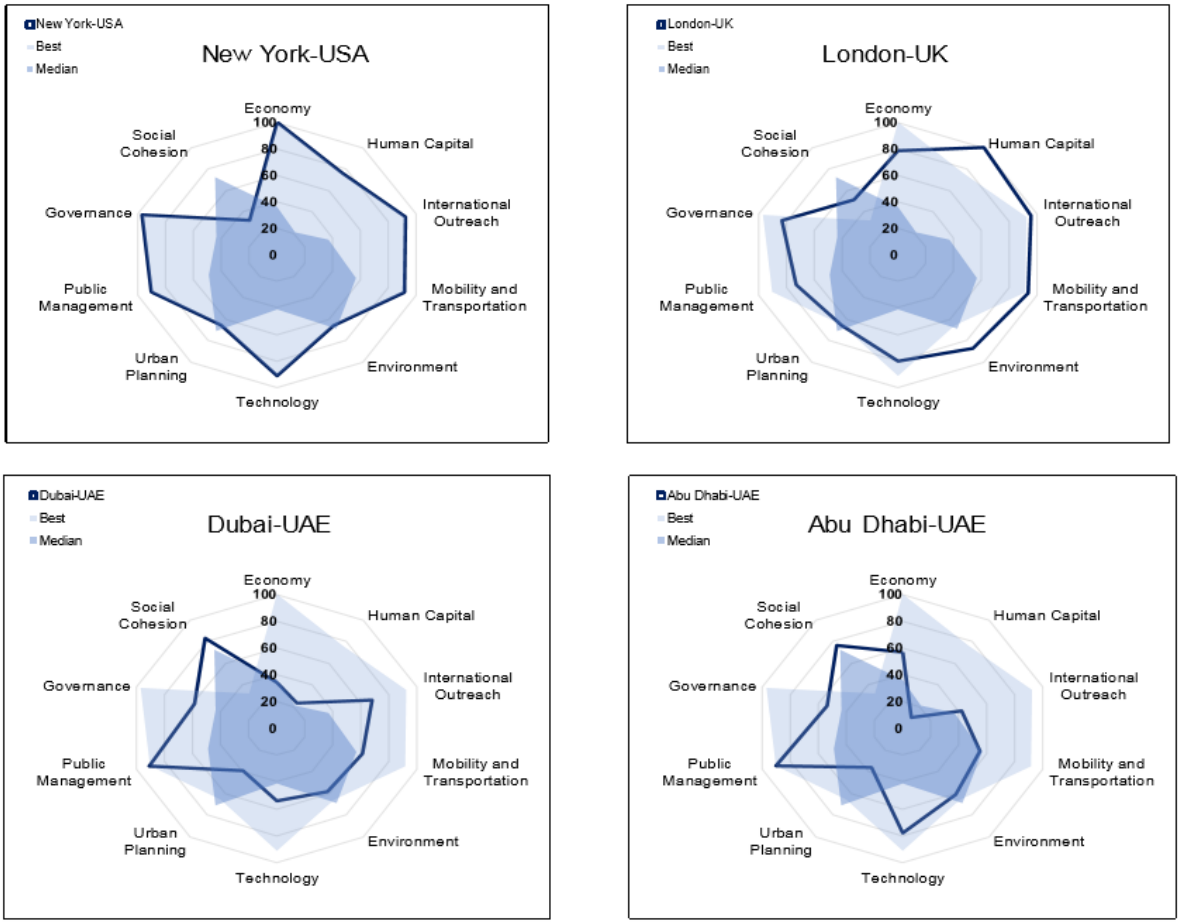


Figure 1.1 IESE Cities in Motion Index (ICIM)**,** source:

http://www.iese.edu/research/pdfs(2017)

Intelligence is the main aim to improve life quality and adopt new technologies without compromising the requirements of future generations.

1.1.1. Smart Cities

This chapter highlight some work solution models, aiming to explore the effects of smart solutions for city developments and to gauge the readiness of employees for smart solutions. These solutions concentrate on the core area of the city including:

- Administration
- Governance
- Education
- Health
- Transportation
- Mobility
- Infrastructure
- Community (people)
- Buildings

Smart City highlights the Information and Communication Technologies (ICTs) importance in the last 20 years (Schaffers, 2012). In literature, the term smart city is used to specify a city's ability to respond to the citizen's needs.

Two main elements are influenced by the city components (Transport, Government services, education, public safety and health). These are the core of a smart city (Choenni, 2001):

1- Quality of life

2- City development

Many other terms were used to define a smart city such as cyber-ville, digital city, electronic communities, flexi-city, information-city, intelligent-city, knowledge-based city, ubiquitous city, wired city.

According to (Choenni, 2001), (Dirks, 2010), (Giffinger, 2007) the most important city system to begin the step towards smartness is the transportation system infrastructure.

The term smart city is also used to identify the education level of the citizens (Choenni, 2001).

If the inhabitants are educated, they will know how to work for city development and they will know of the limits of natural resources. An intelligent educational system (Dirks, 2010) is based on three elements. Interconnection including resource sharing technology, education, instrumentation and intelligence in making decisions that enhance the learning process.

(Dirks, 2009) also highlights the link between the city government and public administration in his smart city definition.

In addition to smart health systems to develop life quality for patients, reducing health care costs and reducing time for access to hospital.

According to some researches, smart city main steps can be summarised as:

a. A base of physical telecommunications network infrastructure, comprised the wiring, the wireless, together with any servers and routers required for operating the infrastructure, with the active employment of ICT (Information and Communications Technology).
b. Applications that facilitate operations in the city, such as traffic control, etc., using the infrastructure provided.
c. The third step is based on connectivity for all.
d. The smart city definition has influenced a lot of cities in the recent years, as many cities have developed and applied smart city initiatives.

1.1.2. Smart cities Benefits and Results:

a. Improving life Quality
b. Increasing the employment ratio
c. Improving research development status and city statics
d. Reduction of greenhouse gas emissions
e. Increasing energy efficiency
f. Improving education levels
g. Managing a data base centre (smart data platform) , which can be shared with all, Open data is now seen as an essential factor of open government achieving transparency and liability and innovation
h. Improve government services and public safety

If the world is to counter effectively to the shortcomings facing it, smarter cities are vital for process. As from 2008, over 50 percent of the total world population now inhabit cities.
A prediction from the UN is that this percentage will increase to 70% by the year 2050. Over 8 out of 10 individuals reside in cities in the UK. Thus cities perform, in a worldwide networked economy, to achieve citizens' well-being in a sustainable manner. Specifically, to become extra smart (Whitmore Group, 2016), the government has determined the following challenges in the UK, for example, which are enhancing changes in the cities of the UK:

- Reestablishment of the economy, following the downturn of the economy, which has degraded unemployment rates, developing flexibility changes in priorities for the authorities of the cities.
- Weak Infrastructures in cities and the increasing numbers of people in the cities are exerting pressure on transport and housing.

- Considerations in climate change, and the reality that 80% of the citizens of UK are city inhabitants, translates that cities have a vital role in advancing energy efficiency and minimizing emissions enhancing reduced prices of energy and the safety of supply.
- The pattern of change towards internet entertainment and online customers or retail services is initialing changes in the High Street.
- Old age has maximizing the burden on social care, to the extent that local authority budgets are under pressure.
- Simultaneously, the pressures on budgets of public finances have reduced by an average of 12-15% for the last three years in absolute terms, with the majority recording 20-30% reductions.
- Grants from the Government Departments are a major source for remote financing as the flexibility associated with Local Authorities relating to Council Tax, and business rates become excessive. Specifically for cities, the remote authorities regard this as a constrain on their capability to provide combined actions of response.

1.1.3. Smart Buildings (Concept Background)

United Sates used the term ‘intelligent’ to define buildings in 1980s. The definition of ‘Smart Building’ was inspired by the growth of information technology and sophisticated demand for ‘human comfort and the requirement for user control and monitoring’ (Harrison, 1998), categorized SBs history to phases “Automated Buildings (1981-1985), Responsive Buildings (1986-1991) and Effective Buildings (1992->)”.

Smart building: the strong relation between all buildings elements (architecture, structure, systems, services and management) demarcated by the Intelligent Building Institute, to improve efficiency and minimize cost (Wong et al.,2005).

1.1.4. Research Motivation

Dubai government vision is to be the smartest city in the world by 2020. Accordingly from the building aspect, there should be a minimum requirement to be considered smart. A survey was implemented in 2016, requiring Dubai to be the smartest in the near future.

No standard for smart buildings in Dubai, (very few studies have been conducted) concerning smart building criteria in the Gulf in general, and specifically in Dubai.

Owners of a building recognize that the measures they use to examine their portfolio are changing. The differing client demands, the impact if climate change and sustainability goals, the reliability of power and constraints of the budget are forcing solutions for the building industry in Dubai. Beyond 2016, owners of a building and vital decision makers will seek to invest in a variety of solutions and embrace the foundation of the technology of the internet. This will lead to changeable, more secure, and free solutions thus enabling the savings in costs; efficiencies in energy and improvements to be made sustainable to the satisfaction of occupants (Cherrayil, 2016).

Regarding these escalations and changes, in the building industry in Dubai, evidence gives credit to the fact that there are no smart building standards in the region. A survey produced by Honeywell Smart Building Score, shows that Dubai and Doha are leading smart building introductions. This survey deals with the assessment of airports, hospitals, hotels, residential buildings and offices together with retail and educational facilities in a range of 620 structures in seven key cities of the Gulf which included the Dammam, Doha, Kuwait City, Riyadh and Abu Dhabi. Honeywell's Middle East president Norm Gilsdorf put it that smart buildings form significant smart cities where each aim to be exemplary, for smart buildings (Cherrayil, 2016).

The score for smart buildings assesses the use of 15 assets to determine the systems in place to contribute to them being green, secure and productive. The overall abilities, the facility coverage, and uptime are then put into consideration. The aim is to facilitate minimal emissions, minimize the production of waste, and manage the usage of water and the quality of improvement of life of the inhabitants. The survey yielded that a moderate smart building score was 48% in the regions of the Middle East. Excluding airports, systems integration and connectivity were seen to be lagging. For the buildings surveyed, 57% were found to possess inadequate efficiency-boosting technology that assists in centralizing information concerning facilities and operations. Regarding asset ability, buildings across the Middle East scored an average percentage of 38. However, this figure can be reduced by smart systems like water leakage and gas detection, fire safety, health fixtures and components of energy efficiency (Cherrayil, 2016).

In 2015, it was noted that most of the houses in Dubai and Abu Dhabi had no appropriate postal system. Thus such a status was a challenge across the globe leading to frustration for people giving directions for deliveries. This led to residents putting reliance on the system of post office boxes so that mail could be controlled from the nearest post office. The street naming was also an implication that the houses could not be accessed with individuals using taxis (Cuthbert, 2015). Dubai city is continuously developing; population reached about 2.6 million in 2016 and buildings should comply with the steady city growth, as shown in below figure.

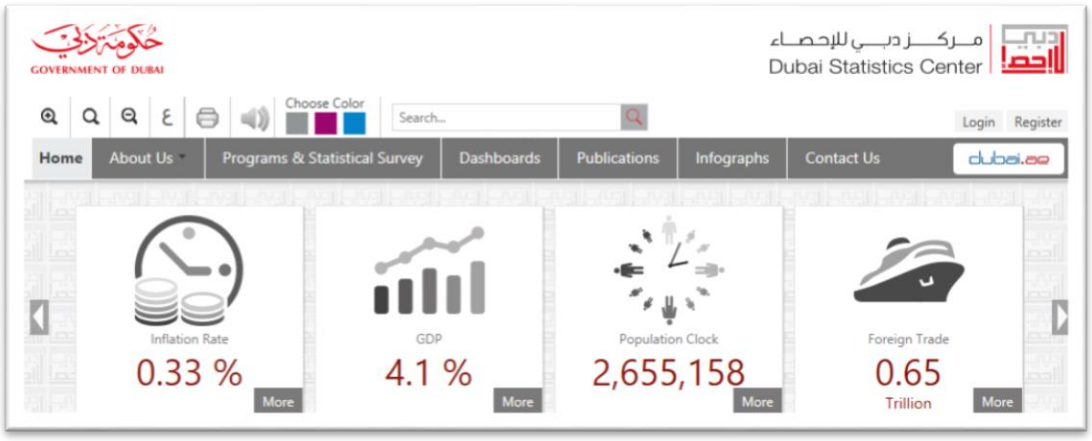


Figure 1.2 Dubai Population Clock, Source: (Dubai Statistic Centre Nov, 2016), available at: https://www.dsc.gov.ae/en-us

Nowadays, the city can't continue depending on using traditional systems and technology as modern systems and continuous life progress. Data and information in substantial and accessible, energy, and natural resources are being consumed.

1.1.5. Research covered aspects:

a. Research statement: There is no smart buildings guideline or framework in Dubai
b. To what extent smart building are needed and why? (Importance and Impacts)
c. The implementation of smart building effect on the economy and the construction sector
d. Smart building implementation experience in other cities in the world is to be considered.
e. Where are smart buildings needed? and to what extent? In Commercial buildings/ industrial buildings /residential /hotels/banks/villas / multi storey buildings.

Until now there are no studies for clear guidelines and specified frameworks to set the boundaries for the revolution is smart building, to prepare for the next phase and what needs to be provided, to consider the building smart in Dubai.

1.2. Aims and Objectives

1.2.1. Research Aim

To develop a clear framework for Dubai Smart Building implementation and rank criteria, in order to have a smart building.

1.2.2. Research Objectives

Objective No.1:

To carry out a comprehensive literature review of worldwide deployment practices for Smart Building Systems to identify the implementation requirements.

Objective No.2:

To explore the readiness of Dubai stakeholders for implementing smart buildings and their knowledge level required.

Objective No.3:

To develop implementation strategy and Criteria Framework Plan.

Objective No.4:

To identify Smart Building Systems and their impacts, limitations and challenges in Dubai.

1.3. Dissertation Structure

The dissertation is five chapters plus the references and appendixes.

Chapter 1- Introduction:

Provide the introduction and background to the study. The rationale behind the study (aims, objectives, the research methodology outline and structure).

Chapter 2-Literature Review:

Include the literature review regarding the main subject of study; 'Intelligent Building Standards and Systems implementation' by reviewing the implementation strategies in leading countries.

Chapter 3-Research Methodology:

Include a brief review on the research methodologies and describes the methodology followed in this research.

Chapter 4- Research Results Analysis:

Include results analysis (survey and interviews results) regarding the assessment of the awareness and readiness of the construction industry in Dubai, for Smart Building implementation.

Chapter 5- Research Results Discussion:

Include results discussion regarding the smart building implementation requirements, the frame work plan, the impacts, benefits and challenges.

Chapter 6 – Conclusions and Recommendations:

Include the final results from the analysis of the author's scientific approach, interviews, the survey findings and analysis. Recommendations for building the implementation method and achievement plan suitable for smart buildings in Dubai.

Chapter Two

Literature Review

2.1. Introduction

The chapter aim is to present a literature review on the Smart Building Implementations studies and strategies in selected cities. This scientific approach through case studies provides an indication of the framework required for smart buildings, in the Emirates of Dubai.

At the beginning, a brief on smart buildings history will be introduced. In the next section there will be a detailed study through the guidelines and the applied rating system used in some special smart building companies and manufacturers. In addition to the best practices and some case studies supporting and applying the requirements for enablers. Finally, recognizing the impact of implementing smart building systems, addressed in the presented study cases.

2.2. Smart Buildings History

The first term used to describe Smart Building was “Intelligent Buildings” in 1981 which was used by UTBS (The United Technology Building Systems). This begins to take place by 1983 in the City Place Building in Connecticut, USA, So and Chan 1999. Despite the limited technologies, the automation in buildings was addressed in a few facilities. UTBS are credited for the smart building initiative in USA, for integrating the buildings into computer networks. UTBS installed and implemented HVAC, Fire Protection Systems and elevators. Through connecting these facility systems to a digital exchange (DPBX) device, communication tools and data tools to improve efficiency

and safety was presented. Also, UTBS lunched the shared tenant service system (STS), delivering communication, automation and control at low-cost including data access and many other services.

There is a belief that around 80 - 90% of life is spent in buildings. Thus, buildings might hold some considerable impact over people's wellbeing, productivity, happiness, and health. For example, a proper, healthy working atmosphere has proved to solve employee's health issues, reduce absenteeism and turnover and provide better performance that can be helpful in considerably reducing the operational costs to employers. Therefore, it shall be ultimately helpful to optimize performance of buildings. In reality, buildings steadily use more power than they might be designed for, and might not provide most efficient working environment for their occupants. Researches and studies in the US show that even LEED-certified buildings have failed to truly reach the promised building operation deficiency (LEED: Leadership in Energy and Environmental Design) (Micro Bytes System, 2015).

The actions taken by occupants of can have a considerable impact on the energy consumed by the building. As an example, setting the 22˚C thermostat temperature instead of 24˚C can reduce consumption levels of energy by over 10 %. A significant lack in efficiency may also be noted in the context of the control and management of various building systems. Studies indicate as well, that facility managers often do not succeed in monitoing, coordinating, and optimizing the the performance and efficiency of building systems such as HVAC (Micro Bytes System, 2015).

Advancements made recently in the gathering data, analysis, and communication present new chances for more intelligent designs or smarter structures. During times of functioning, smart buildings use IT for :

- synchronizing and linking building sub-systems that in general operate individually

- communicating and engaging with occupants of building.
- connecting and responding to the demand-side management strategies through the means of smart grids.

Current buildings have complex or advanced mechanical and electrical systems which require a higher grade of management, control and maintenance, mainly applied commercially, particularly in high rise buildings (Braun, 2007). Moreover, these frameworks need to communicate proficiently and work for the execution of the futuring buildings. A case, for a ventilating framework can be made to accomplish ideal ability by:

a. Gaining climate information from open air sensors to decide how much outside natural air to use.
b. Analysing occupants activities to decrease the cooling of empty building regions. Building Management System or BMS, in addition, alluded to as Building Automation System or BAS, is a PC based framework that can be utilized to screen and control different building frameworks. It comprises of equipment segments, for example, sensors, which gather continuous information from the building, and programming programs that break down this information and make an interpretation of it to those that carry on activities for different building frameworks. The trading of data is ordinarily accomplished through wired and remote correspondence systems, which can concentrate pertinent building data and controls in one area for simple access to office managers. The process of detecty and fixing potential faults in building systems is also facilitated (Micro Bytes System, 2015).

2.2.1. Smart Buildings Concept

Smart Building Concepts were developed to introduce control, automation, data, communication and technology, in order to have more efficient, commutable, productive and safe buildings. (Wen and Hsiao,)

The appearance of smart building was due to the rapid evolution of communications and new technologies. This evolution was a result of the energy efficiency and the awareness of the importance of sustainability and the intelligent use of energy in buildings. Smart Buildings use smart communications technologies which provide (monitoring, control, operation and building management).

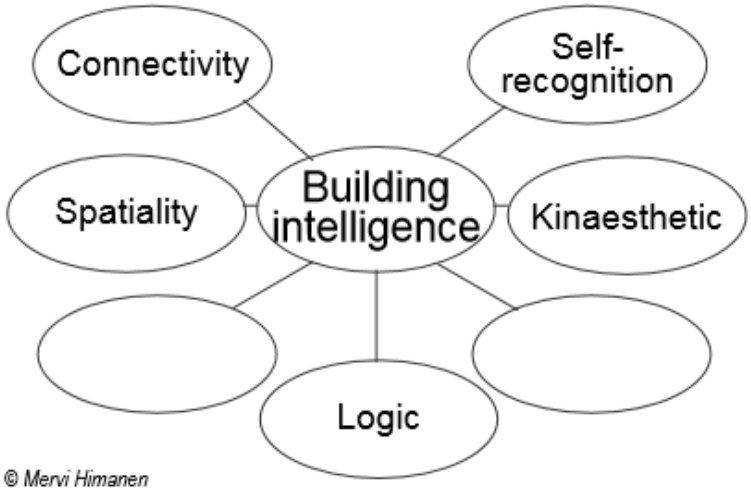


Figure 2.1 Smart Buildings Forms, source: (Himanen, 2003) available at: http://www.vtt.fi/inf/pdf/publications/2003/P492.pdf

2.2.2. Building Types

As per Dubai Statistics Center, the number of completed buildings reached more than 10,000 in 2016. As shown in figure 2.2 the completed buildings in Dubai can be classified by each type monthly.

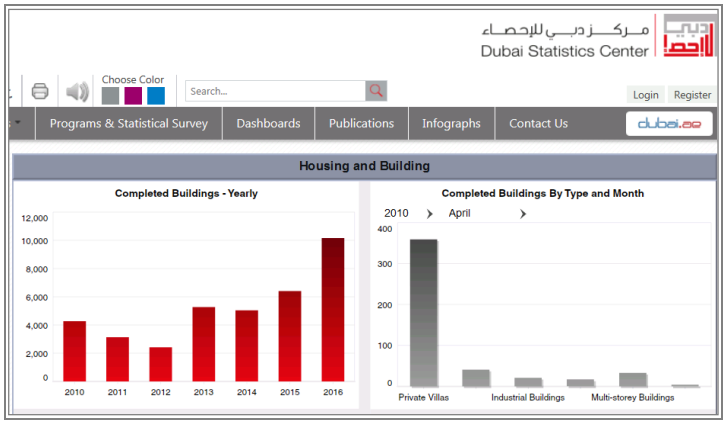


Figure 2.2 Completed Building statistics, source: (Dubai Statistic Center, 2017) available at: https://www.dsc.gov.ae/en-us/Pages/HousingBuilding.aspx

2.2.2.1. Residential buildings

Modern smart building technologies are entering the market. Thus it translates into a greater options for building owners in matter of investing in upgrades in energy efficiency. Sophisticated controls driven by data, that was once only available to espencive equipment, has now appeared frequently in superlative, economic systems. In the case of energy efficient upgrades, emptying pockets of "smart" technology might not bring up the best money conservation. Smart buildings reduce adverse human impact and enhance focuses on the improvement of new technologies. Specifically, the "Internet of Things" that contributes to the lifestyle, happiness, productivity and well-being of the occupants. To achieve this, it needs smart buildings with minimal

emissions. There is a reduced production of wastes with water usage management thus an improvement in the quality of life of the inhabitants (Micro Bytes System, 2015).

2.2.2.2. Commercial buildings

The advancement towards smart buildings, efficiency in energy utilization, and reduced emissions of carbon is important. Adopting the technology of smart building in commercial and real estate is now enabling various owners of buildings to be economic while enhancing sustainability and reduced reliance on fossil fuels (Casey, 2013).

The Steve L. Newman, of the Real Estate Institute in 2010, in New York City, at Baruch College produced an article concerning the emerging case for embracing smart technologies in commercial structures. The focus of the article is on the significant increases in efficiency that occurred when residents of buildings access real-time information on their utility usage. “Cloud-linked” smart technology in building has continued to expand in cities. An example, in New York, and other regions, since the article’s publication to conclusions are still critically relevant for those of regarding the idea of adopting smart metering in commercial structures.With the upgrading to efficiency made from implementing the current system, in commercial buildings, can conserve about 2,000 kWh, on week days. On weekends more conservation can be achieved. This adds up to energy savings of 730,000 kWh a year. A 15% reduction in energy consumption and a reduction of 524 metric tons of carbon emissions. Applying smart metering to be able to identify, where important savings can be made enable planners to reach significant changes. This prompt feedback regarding the effect of the particular changes were important. This data provides a map for personnel to create more efficient systems(Casey, 2013).

It is time for building owners everywhere to consider reducing waste and inefficient energy use. The research Support Facility (RSF) is the nation's largest ultra-energy efficient building and a prototype for the commercial building industry. The RSF is designed to use 50% less energy than a conventional office space at a comparable cost. Design features include passive energy strategies and renewable energy technologies. The Energy Systems Integration Facility (ESIF) is central to the future of NREL and the nation. It will resolve issues associated with transforming the electrical grid adding new renewable energy generation systems, whilst reducing the risks of new technology adoption (Whitmore Group, 2016).

2.2.2.3. Industrial building

Smart equipment comes with the potential for interacting with grid-supplied energy, in industrial facilities, in ways that can give advantages. For instance, a discussion as how variable-rate motors could be tuned to accept lower off-peak utility rates. In 2008, a report published by the Federal Electricity Advisory Committee implying an automatic adjustment to the warmth produced due to greater occupancy at various times of the day. This also can denote adjustment to warmth produced by appliances and equipment. These can result in a difference in industrial and commercial buildings than in the case of residential buildings (Casey, 2013).
Another freqently considered example is the smart thermostat. Standard ones may have the option for remote set-ups using a timer. Howvever, that adjustments can typically be done just a few times a day. On the other hand, advanced thermostats have capacity to quickly and correctly adjust according to the ongoing temperature variations in a building. One major denominator with smart structures is the utilization of electronic equibments to keep track of the utilization of energy and adjust devices that consume energy. An example which works equally for commercial, industrial and residential buildings can be motion-sensitive lighting. It ensures there are no working lights in unused rooms (Whitmore Group, 2016).

2.2.2.4. Smart building in airports

Operations in Airports and business models have notably evolved over the last 20 years to support the improvement of the airline industry at a global level. Reforms in

regulations and deregulation have ushered in a new aviation era. Emerging countries are showing dramatic traffic growth, diversity, and choice of airlines (Senseware, 2016).

Following increasing competition in the airline industry, airports are increasingly more responsive toward passengers' needs. This is directing them to focus on cost reduction and innovation along with choice and value. Smartphones penetration and tablets are playing a major role in enhancing the global outlook of smart airports. A combination of facilities of mobile check-in gives service differentiation and cost reduction to the customer. Smart airport structures include; communication systems, endpoint devices, cargo, passenger, and ground handling control of baggage, security systems, air traffic control, among others (Senseware, 2016).

Due to the numerous attacks from terrorist and other concerns regarding security in the year 2015, the sector dealing with the security systems lead in the market due to a range of government initiatives. For airports, smart solutions was adopted. However, solutions of the terminal side are expected to expand at the fastest rate in the future due to the increasing focus on lifecycle services and digital video surveillance and management solutions (Senseware, 2016). Among the smart airport applications, the core applications segment had the largest share of the overall spending on smart airport applications. This is due to the advancement in the use of mobile devices to check flight updates, baggage status, and other information. To provide such information through mobile notification services, airports, as well as airline operators will have to invest significant sums in core applications. This segment is expected to remain dominant during due to the high demand for integration of applications to track, manage, and share viable information, that is up-to-date in real-time, with all the shareholders of an airport environment (Senseware, 2016).

Smart airport services include; parking and smart transport, smart hospitality, smart retail, as well as entertainment, smart workplaces, airport processing and smart B2B services. Among these, smart B2B services for airports are the greatest section of global airport services in terms of revenue, in 2015. This is due to the incresing demand for continuously updating passengers with real-time travel services such as valet parking and route switching (Senseware, 2016).

2.3. Smart Building Systems

2.3.1. ICT Technology and Buildings Control

ICT (Information and Communication Technologies): systems integration, online data and information security for software application development. This includes connecting computers, LAN, and building through system integration of software and hardware, which includes the following aspects:

- ICT Integration: server system, information security solution, security operation centre, large-scale WAN/LAN, IP (Internet Protocol) /PBX system, etc.
- Cloud: to minimize servers cost and enhance its efficiency.
- Software Application regular maintenance, system maintenance and updates.
- Data storage and mining, large data analysis.
- System Development and customization options.
- Buildings Information Bank.
- Wireless technologies, such as ZigBee (Egan, 2005; Duan and Li, 2008), wireless energy sensors (electromagnetic waves, solar, temperature, occupation and vibration).

- Open protocols for integration and control of multiple building systems, such as KNX/EIB in Europe (KNX, 2011), BACnet (Bushby, 1997; Holmberg and Bushby, 2009) and Lon Works (Echelon, 2009) in America.
- Interfaces of Web, mobile and energy dashboards (Negron and Hayes, 2009), to view data, energy consumption and effect user behaviour. (Agarwal et al., 2009; Bartram et al., 2010)

2.3.2. Smart HVAC

HVAC is a complex system in buildings, with many parts organized to yield cooling, heating and ventilation through thermodynamics principles, fluid mechanics and heat transfer. The system makes the building convenient, heathy and comfortable, controling the energy consumed also, along with playing an essential role in safety. In the context of maintainance of the air quality of the building, the HVAC system should react to a variety of interior and exterior factors of the smart building (involving time of the day, weather, different kinds of spaces within a structure and occupancy of building) and should do so while operating at optimum with the utilization of energy. It necessitates automation and system integration, given the diversity of conditions along with the potential complexity involved in HVAC systems. As an example, the HVAC system to automatically sequence pumps, chillers, boilers, etc. along with automatically rotating parallel pumps, chillers, and boilers by monitoring the run-time, in a smart building. The HVAC system also must give an optimal start calculation on the basis of real occupancy history (Sinopoli, 2013).

Check of the HVAC system for occasionally using facilities such as rooms of meeting, conference rooms, cafeterias, etc. is also vital in the context of lowering the energy consumption. HVAC for spaces needs to be integrated into another system that can

assist in the supply data of HVAC regarding occupancy or usage. They include data from video surveillance, access control system, lighting control, people counter system, an RTLS/RFID system for the occupancy sensors (Sinopoli, 2013).

2.3.3. Smart lighting

Introducing smart lighting solutions into the various buildings some considerable amount of money for energy related expenditures. At the same time, it reduces emissions of greenhouse gases. Smart building pays out around six hundred million dollars per year on electricity for public institutions and its agencies (Sinopoli, 2013).

To help decrease smart buildings energy bills and reduce emissions of gas, the DCAS (acronym for Department of Citywide Administrative Services) triggered an innovational program for finding out and funding projects that were cost-effective and energy conserving, in urban regions. Today, the ACE (acronym for Accelerated Conservation and Efficiency) program has brought roughly a hundred and ten energy conserving projects across eighteen city agencies, valued at two hundred and ninety million dollars in New York City.

A variety of agencies have put the installation of smart lighting adoptions in their structures, including advanced lighting controls and LED upgrades. As for instance, New York City Fire Department secured Accelerated Conservation and Efficiency resourcing for installing the LED lighting in over eighty firehouses and fire department offices across 5 boroughs. FDNY facilities have the potential for significant energy savings because of their operations 24/7. Some benefits are offered by LED lighting which includes lower costs of maintenance, high quality lighting as well as higher longevity (Sinopoli, 2013).

Another important features related to smart lighting systems are switchable glazing and smart windows, the capability of controllable motor-powered blinds for reducing energy used. New technologies, give options to control and adjust effect of heating, cooling loads and day lighting. Window opacity for instance, can be adjusted during summer to control and reduce HVAC loads, another common technologies are:

- Electro chromic openings: based on chemical reactions, activated by the quick apply of power, to adjust the opacity of windows' glass through multiple layers. (Apte et al., 2003).
- Gas chromic openings: dynamic film layer (WO3) which reacts through filling hydrogen in the hollow, to adjust shade and transparency of glass (Wilson et al., 2002). This has converting speed quicker than that of electro chromic methods (Carmody, 2003).
- Thermo chromic openings: the visual adjustment of glass is based on temperature, although this technology isn't easily controlled as the electro chromic windows. (Fraunhofer IAP, 2008)

2.3.4. Smart Security and Monitoring

Smart building seeks to achieve security issues by actual detection and prevention of intruders through smart walls while monitoring seeks to achieve the quality of water, air, temperature, and electricity. In gunshot detection, an example in New York the Domain Awareness System (DAS) includes hundreds of NYPD video feeds, plate readers for licenses, radiation and chemical detectors and 911 reports into a central clearing house. Also, it also combines the data feeds obtained from different City agencies and some commercial and private buildings. To improve the Domain Awareness System and enhance gunshot incident response time, NYPD brought in the

technology that supplies the agency with same-time acoustic gunshot disclosure. For monitoring, the systems are connected automatically such that when the level of required quantity of water, air, and electricity falls below the critical level, alerts are sent as notifications to the users and those in charge of replenishing who in turn take appropriate action for a corrective action. Thus a single system can check lighting, air temperature, and the security of a building. A manager, at home can use his personal computer to tell whether the temperature is too cold on the fifth floor of an office building. Using the same system, a security guard stationed 1,000 miles away can detect an intruder in an office building (Sinopoli, 2013).

2.3.5. Smart BMS

Smart BMS is the driver of advanced buildings, depending on systems complexcity, such as rainwater harvesting, exterior shading, water reclamation, renewable energy (solar panels), sun tracking systems, electrically switchable glass, etc. Maximizing efficiency for each one of these systems is required, increasing the load and challenge for facility management. Another factor responsible of greater complexity is in relation to decisions in management for the operation of building services. The major patr of all these decisions cover numerous variables, along with some circumstances asking for real-time decisions. For instance, a demand response occuring from a utility that needs an immediate action. Drwabacks of typical BMS is actually long a list. So considerable ones are insufficient and primitive analytic tools, limited integration capacities, a dearth of software applications and interfaces of the legacy user, proprietary programming languages etc. A smart structure will have an improved system management for a building with a programming prtocol that is open, which could combine different system softwares. It needs middleware to standardize and normalize combined data from sub-systems into a database that is open, standardized, mainly applying SOAP/XML or any other exchange architecture software. The database can compose all practical, calculated as well as imaginary points. The user interface to the advanced systems are displays and dashboards totally customizable as well as configurable by respective users, with an access through a browser. The system shall have capacity for exchange of data with the informations in business and enterprise level softwares. These provide a suite of software applications like alarm management, building performance analytics, energy management, and also, automatic fault diagnosis or detection (Sinopoli, 2013).

2.3.6. Smart Fire Fighting

Some components and specifications such as (Coordination of advanced FF sensors, Coordination of dispatch data, use of building data, Real-time fire status updates, Real-time weather/wind data, Real-time use of water supply data, Real-time use of traffic data, FF location/situational detection, Reliable predictions and analysis of fire spread) make the fire fighting system a smart system (NFBA, 2014).

2.3.7. Smart Water Systems

Control pollution through smart water quality monitoring networks, water recycling, control irrigation through smart valves and pumps, control and measure the water consumption.

2.3.8. Smart devices

Remote access and control of home, hotels, pubic buildings and office smart appliances such as (printers, TV, fridges, washing machine...etc) through internet, PC and mobile.

2.3.9. Other Smart systems

For example, smart parking that assist cars drivers to find a vacant parking using sensors to detect the presence or absence of a car, signs direct incoming drivers to available locations. Other system is smart elevators, through providing a smart control system to direct occupants to the elevators that is headed to the selected floor, with the least number of stop, these systems are faster, easier and further energy efficient

2.4. Best Practice and City Selection

In this section, selected countries have been examined, as best practices. To be a good study reference, through exploring these cities' experience. However implementation may differ from country to another.

Smart Building around the globe in London, Taiwan and Zurich: Reports from city mayors detailing blueprints preparing for future times were been issued. We project a city having a thriving and dynamic economy which can also be a responsible care taker

of the environment. Equity is an explicit guiding principle in this work, and amplifier through which all of their policymaking, planning as well as governing is depicted has been proposed. Equity means they will ensure that every individual in the cities has unbiased opportunities for achieving the person's full potential as well to succeed. The focus is much put on smart building lighting, water meters that are wireless, traffic management response, smart management of waste, monitoring of water quality and air, gunshot detections once and service requests that can be available 24/7. These efforts represent the diversity of ways that connected technologies can help improve government services and better the lives of all individuals in the cities and communities across the three cities (Blasio, 2014).

Taiwan Strategy initiated a conceptual detailed development towards merging the sustainability with IT to enhance life quality indicated in below figure (Chin Ho, 2011), to solve the main three issue in the city (climate change, aging community and dropping energy resources).

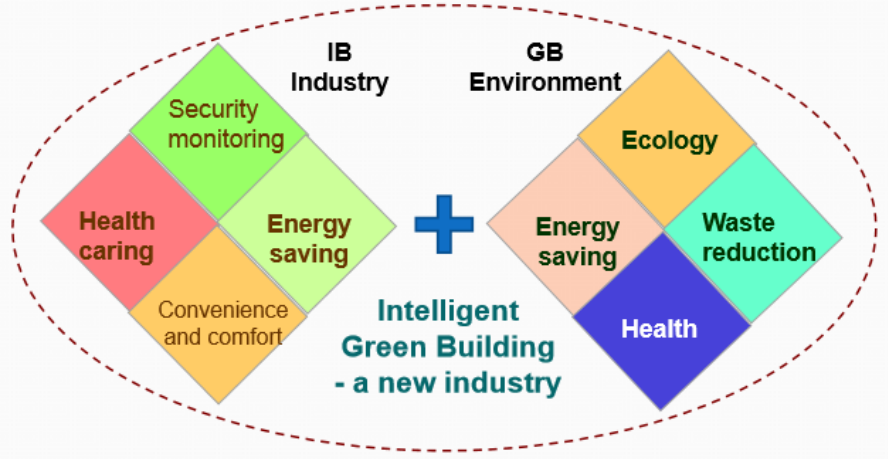


Figure 2.3 IB Label and GB Label, source: (Asia Pacific Intelligent Green Building Alliance Conference, 2014) available at: http://apigba.org

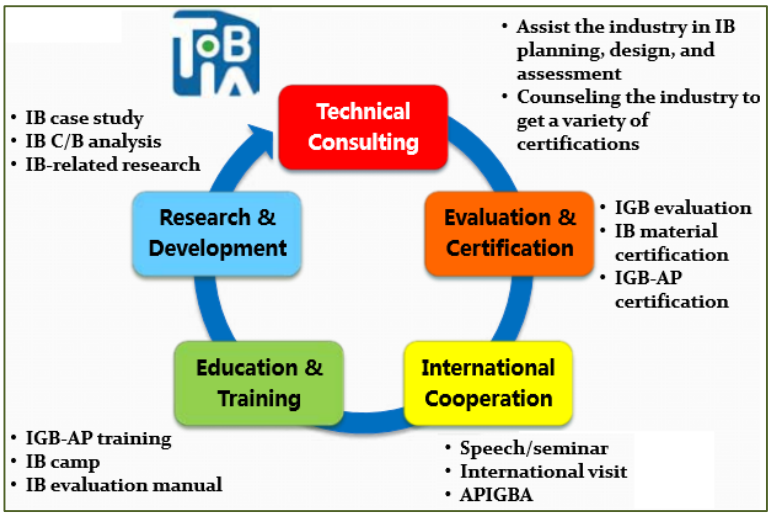


Figure 2.4 Main Areas of Developments, source:

(Asia Pacific Intelligent Green Building Alliance Conference, 2014), available at:

http://apigba.org

The institute categorised Smart buildings to three Accredited Professional:

- IGB AP TIBA : Intelligent green building
- ISB AP TIBA : Intelligent safe building
- IHB AP TIBA : Intelligent health caring building

The evaluation process was divided into two main categories (Infrastructure, Functions), each category includes 4 indicators:

- Infrastructure: wiring & cabling, Data and communication, integration of systems, facility management.
- Functions: safety, health & comfort, convenience, energy efficiency & management.

The smart building assessment level included:

- Building Environment

- Construction Cost
- Smart systems
- Management Use

The resulted benefits of applying smart building grading system shown in Figure 2.5, as per TIBA were (ÅWen, show-ling: Evaluation of the Cost-Benefit Analysis of Taipower's Intelligent Buildings):

- 11% energy savings
- 4% increased efficiency
- 20% improved indoors space quality
- 20% increase in rental rates
- 6% savings on operation cost
- 113% increased employees production

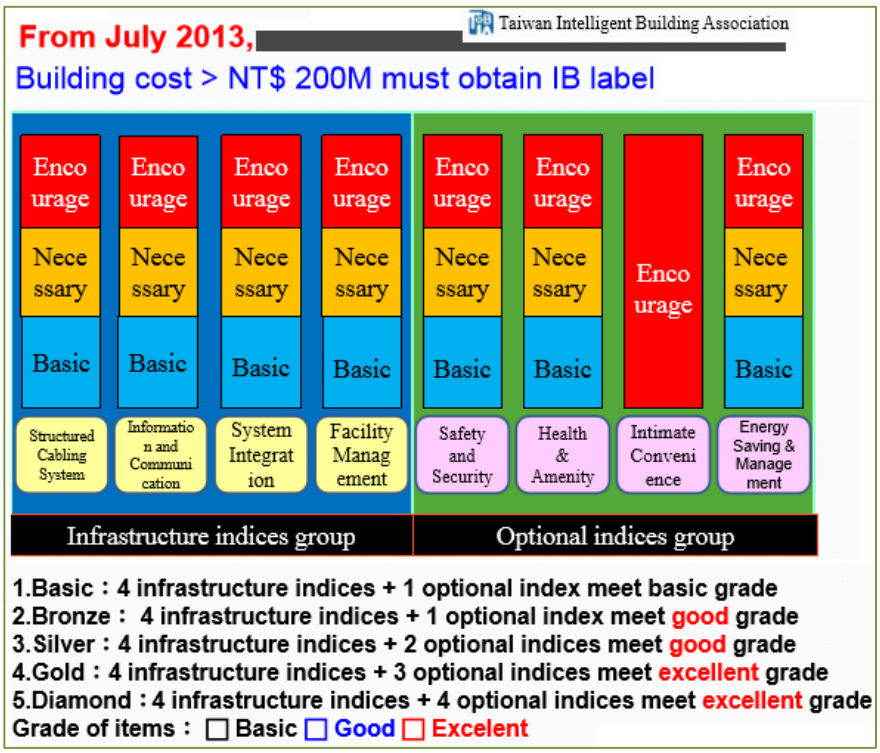


Figure 2.5 Evaluation & Grading system for Intelligent Building 2011, source:

(Asia Pacific Intelligent Green Building Alliance Conference, 2014)

available at: http://apigba.org

As shown in above figure, grading includes (Basic, Bronze, Silver, Gold and Diamond), where Diamond grade is the excellent grade (building meets all 8 indices).

2.5. Smart Buildings Implementation Enablers

2.5.1. Technology

Technology is moving and developing rabidly parallel with the city development which is an important and effective enabler in applying future technologies for implementing smart buildings. Open protocols which are adding more features every day to the software's and the smart building applications.

2.5.2. Guidelines and standards

- PAS 181 Smart city frame work (SCF): This PAS establishes a good practice framework for city leaders to develop, agree and deliver smart city strategies that can help transform their city's ability to meet future challenges and deliver future aspirations. PAS 181 Smart city framework. Guide to establishing strategies for smart cities and communities do not intend to describe a one-size-fits-all model. Instead it focuses on the enabling processes by which the innovative use of

technology and data, together with organizational change, can help deliver the diverse visions for future UK cities in a more efficient, effective and sustainable way.

- ISO 37120 : New Smart city standard by Smart cities Council as shown in below figure which includes 46 core , the main indicators related to Smart buildings is:

  a. Energy consumption of public buildings per year (kWh/m²).

  b. Telecommunication and Innovation which indicates no of internet connections per 100000 populations.

Figure 2.6 ISO 37120 Smart Cities Council, (Smart Ccities council, http://smartcitiescouncil.com, 2016)

2.5.3. Regulation and policies

- Unrestricted Telecommunications policy: to implement telecommunications open policies and law to have limitless transmission of data as a key for information data base for the city buildings.

- Applying governance regulation specifying the boundaries for the mandatory implementation and setting a rating system plan.
- 2021 Dubai Plan, to have important governmental KPI's related to the element of "Place" which aims to be a smart, integrated and connected city through the city infrastructure and building development to increase efficiency and support targets such as CO2 emissions, as shown below:

Table 2.1 Dubai Plan 2021KPI's, (Dubai Plan 2021, 2016) available at: (http://www.dubaiplan2021.ae)

KPIs	
1	Satisfaction with the Infrastructure of Dubai (by area)
2	Rate of carbon dioxide emissions per GDP
3	Annual solid waste generated by the city per capita
4	Average response time to different emergencies (police)
5	Average response time to different emergencies (civil defense for fire accidents)
6	Average response time to different emergencies (ambulance)
7	M-completion
8	Road fatalities per 100,000 population

2.6. Chapter Conclusion

Smart building in the past was only achieved as a feature to enhance more attraction of residents to live in these houses. However, in the current times, features of the smart building are embraced to keep pace with the competitive environment in the field of rental housing and the comfort zone of occupants. This will facilitate them maintaining the competitive position, to enhance high standards.

The aim of the smart building is to reduce adverse human impact and enhance ecosystem focuses on the improvement of new technologies specifically the Internet of Things to enhance a static arena that contributes to the lifestyle, happiness, productivity and well-being of the occupants. To achieve this needs that smart buildings possess minimal emissions, there is a reduced production of wastes, water usage management thus improvement in the quality of life of the inhabitants (Rotana Times, 2016).

The human resources consumption would also be managed in the achievement of the smart building. These would be reached through:

- Higher security, automation systems that give protection around the property thus preventing unauthorized access and minimal theft.
- Smart notifications and alerts –Emergency alarms that can converse with the head station that is in charge of monitoring where information is relayed by email, text notification, in real-time. This enhances tracking and faster detection thus notifying the main company of any security issues.
- Back up of communication – The information communicated through these security systems can be stored in a cellular form enabling easy tracking and safety. This saves the storage space and costs.

Chapter Three

Research Methodology

3.1. Introduction

The aim of this study is to set a framework for rating smart building in Dubai. The next step after completing the literature review is to specify the research methodologies to be implemented, in order to reach the study aim and objectives addressed in the introduction chapter. In this stage, start the initial design of questions and the suggested gained results of these questions (Naoum, 2013).

This Chapter will summarise the methods embraced and adopted for the research. The first section demonstrates the research methods used, the second section including the research approach, data collection techniques and the survey design.

3.2. Research Methodology Outline

Step One:

Outline Data Sources and literature review

Step Two:

Identifying Research Approach and Tools

Step Three:

Analyse the collected data and evaluate results

Step Four:

Set the initial and final conclusion and recommendations

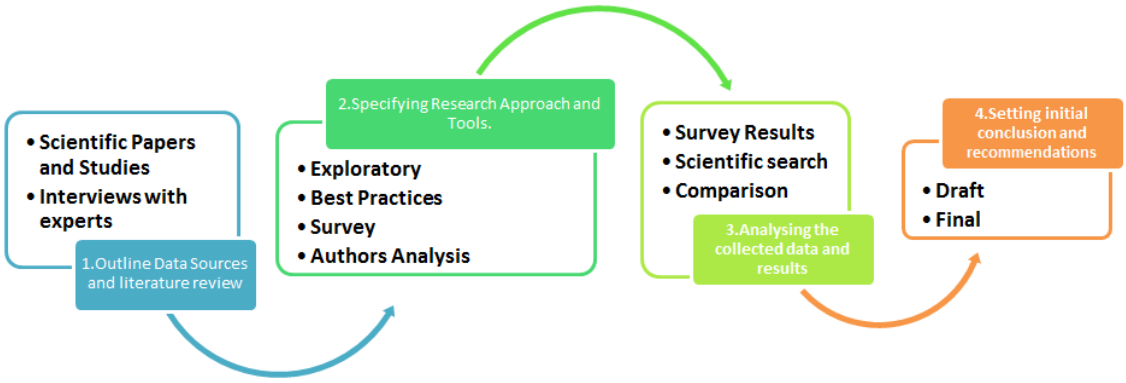


Figure 3.1 Methodology outline

In Figure 1.3, the methodology outline is summarised. Viewing the framework for a case study and applying smart building quantitative and qualitative research, exploratory research techniques using survey as a research tool can be specified. The targeted sample unit, size of the study, from the preparation of owners, vendors, consultants, contractors and developers for the smart solution was obtained, in addition to conducting interviews with Dubai Municipality experts and smart solutions companies, as a final step setting the framework assessment, was established.

3.3. Research Methods

Research methods and strategies was demarcated to be the way the research goals could be asked and investigated (Naoum, 2013), to find the best method to ask about the research objectives and goals, in order to collect targeted data and information, identified as follows:

3.3.1. Quantitative Research

Aims to register data collected in statistics, resulting generalized participant selection (sample) to take the measures represents general category (Alzheimer, 2009).

3.3.2. Qualitative Research

Aims to collect participants' experience, a better method for engineering management researches related to construction (Seymour, 1997) to focus on specified concept and participant's opinion for data which could not be measured.

3.4. Research Data Approach

A systematic, and scientific approach (Alzheimer, 2009), for primary data and secondary data collection suggested in Naoum study (2013). The primary is through fieldwork (survey, case study, problem solving). Whereas, secondary is through a desk study in statistical and descriptive layouts.

3.5. Research Methodology Selection

The aim of this research is to develop clear assessment framework for Dubai Smart Building guidelines and implementation criteria, through identifying the best practices in countries, local markets, and putting in consideration the participant's opinion for the smart building implementation frameworks, and to draw the boundaries for the study, through implementing a part of the full picture.

There is many studies on Smart Building concept, in the contrary of the implementation framework to apply smart building in Dubai. Rating it, via the few studies done in MENA region, that's why method used in this study was an integration of qualitative and quantitative (Alzheimer, 2009). A literature review, in addition to interviews

conducted with vendors, finally implementing the survey with the different stakeholders related to the construction and building sector.

3.6. Survey Design and Data Technique

3.6.1. Sample

In this research, the sample selected to take their feedback was from different participants categorised into four main stakeholders, related to the study aim:

- Governmental Sector
- Private Engineering Sector
- Building Owners
- Vendors and Manufacturers

Each of them represents a major role in the implementation process, shown below:

- Governmental Engineers and buildings experts, responsible for regulating and permitting buildings in Dubai.
- Consultant engineering offices who are responsible for Building design, permitting and supervision process.
- Contractors Companies who are responsible for the executing of the projects and buildings (from drawings into real buildings).
- Owners who purchased and experienced smart building systems, and the large project developers in Dubai such as EMMAR.
- Vendors and Manufacturers from different smart buildings vendors and specialists companies (large and small firms) such as ABB and Honeywell.

After the approval of supervisors and Building Department, the final survey it was distributed by two methods, through BPCS (Building Permit and Control System) by online general message option available in BPCS, to collect the responses of the active users in BPCS (the private engineering sector), the second method through distributing it manually during working hours in governmental sector (Municipality) and while visiting the interviewed firms and companies.

The responses to survey were collected within 10 days, through hand, e-mail and online messages from BPCS. The total count of the collected responses reached 105 answered survey.

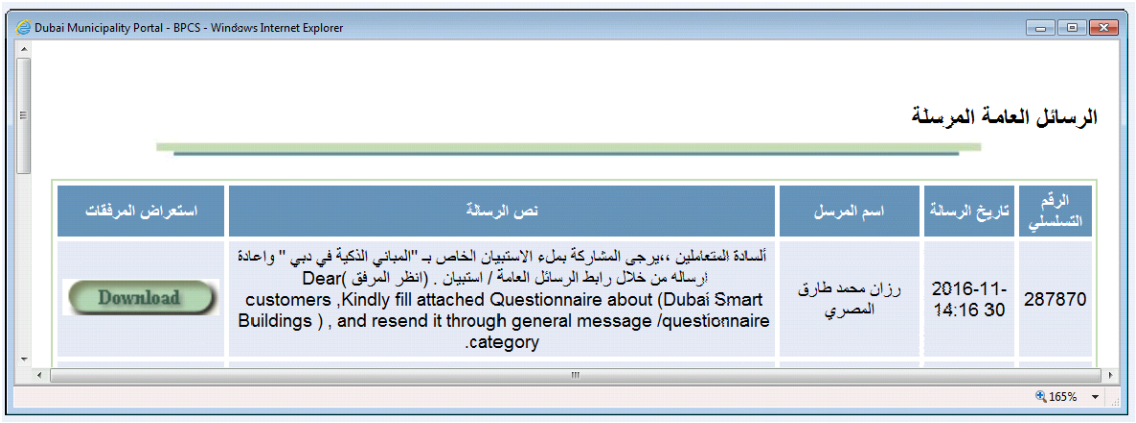


Figure 3.2 General Message sent though BPCS, source (Dubai Municipality, Building Department, 2016)

3.6.2. Survey Format

The needed responses in this study had to be direct and specified (Naoum, 2013), and many data is needed from the participant so a quick, easy and direct survey format is required , for that reason close-ended survey type was selected in the survey format for this research.

3.6.3. Survey Structure

The survey was divided into 6 main sections:

- The first section of the survey is **Bio Information** to collect some general information about the participant's profession and experience.
- The second section of the survey is **Smart Buildings Knowledge Level**, to know the participants awareness level on smart buildings.
- The third section of the survey is **Significance of Smart Building Guidelines**
- The fourth section of the survey is **Smart Building Guidelines Implementation and phases**.
- The fifth section of the survey is **Cost and Impact of Smart Buildings Systems**.

3.6.4. Pilot Study

Pilot study was done on selected participants; one of them was the building expert in DM , the other was BUID supervisors, to take a second eye and opinion of experts, before the final distribution and publishing the survey, the draft survey was too long and needed more direct approach. The pilot study and participants' comments enhanced the survey structure to reach the final survey version. (Refer to appendix A-2: Draft Survey).

3.6.5. Data Analysis

The final survey includes five sections, each of the first three sections included 3 to 4 questions, which were short. The last two sections had the complicated and the core of the survey which needed more analysis while answering. The questions were related to

the research objectives and aim, data were calculated manually through excel file formulas and diagrams.

The descriptive method was used through a data analysis process, using the bar and pie charts to have direct and general overview of the results.

3.7. Chapter Conclusion

The phase of collecting data is very critical. The most important phase to research study success, aims to create a framework for implementing smart building in Dubai and the stakeholders' responses to the new building vision. The other critical and important phase is analysing the data which was collected through the literature review, interviews and survey, to design the assessment framework plan through combining all phases.

Chapter Four

Research Results Analysis and Discussion

4.1 Introduction

In this chapter survey results and analysis will be introduced. Presenting survey responses for each section, and interview results, achieve the stakeholders' strategy in implementing smart buildings in Dubai.

4.2 Survey Results Analysis and Discussion

4.2.1. Section one: Bio Information

(Question from 1 to 3)

This section of the survey is to collect general information about the experience and experience type of the participants.

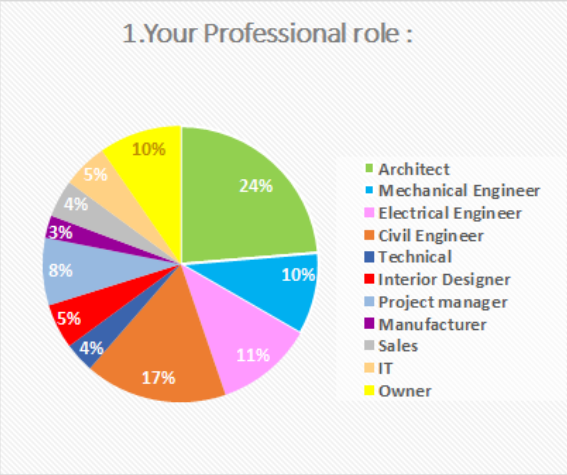


Figure 4.1 Professional Role

Figure 4.2 Organization Classification

In question no.1, the percentage of buildings owners who participated in the survey reached 10%, also participants from different engineering disciplines responded with the following percentages:

- 24% were architects
- 17% were civil and structural engineers
- 11% were electrical engineers
- 10% were mechanical engineers
- 8% were project managers

Question no.2 in figure 4.2 shows the responses percentage for the participated stakeholders:

Governmental sector reached 36% which was the highest category of response, the second highest category was the consultant engineering offices from the private sector with a response reached 21% , while contractors companies from the private sector responded with 10%, as mentioned previously the smart building vendors response reached 16%, where 6% for building systems vendors, as far for the Major Projects developers and investor the percentage reached 11%.

The smart building systems vendors and suppliers response reached a total of 16% which was (4% Sale, 3% manufacturers, 5% IT, 4%technical), remaining responses were 5% interior designers.

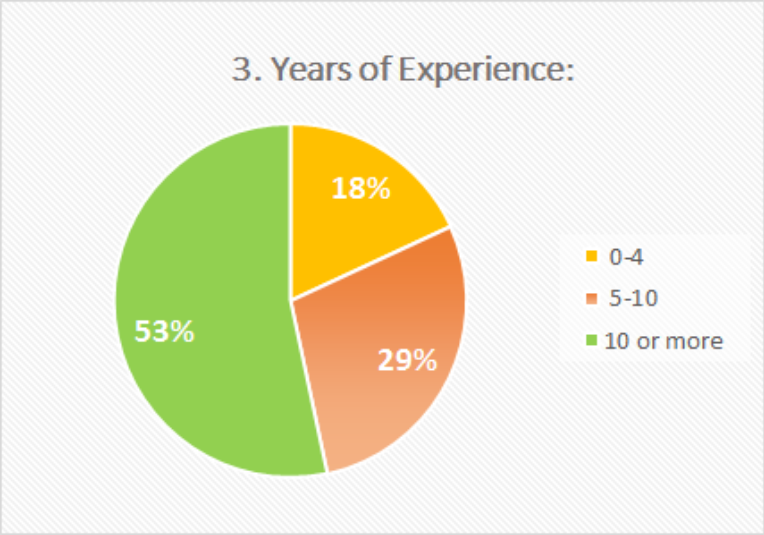


Figure 4.3 Years of Experience

Question no.3 shows the percentage of years of experience, as noted in figure 4.3, more than half of the participants have 10 years or more of experience, 29% were from the category (5-10) years of experience, and 18% have 4 years' experience or less.

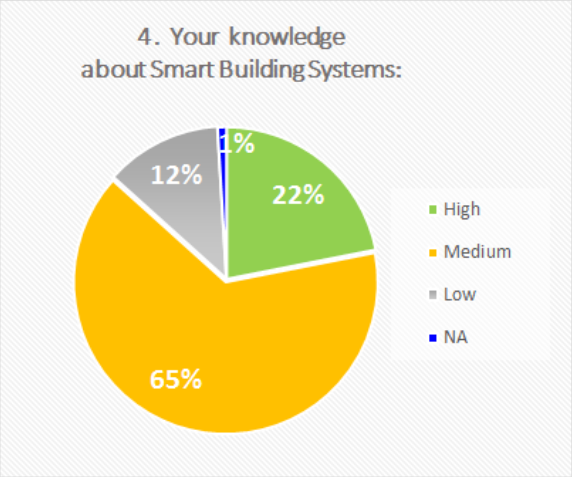
Section-1 conclusion:

In the first section of the survey questions, the higher response was indicated from the governmental sector and the private engineering sector, and most of the participants with a high level of experience of building regulations and construction sector.

4.2.2. Section Two: Smart Buildings Knowledge Level

(Question from 4 to 7)

This section's is to evaluate the knowledge level and the awareness of the participated stakeholders regarding the smart buildings concept, smart building systems and implementation motivation in Dubai.



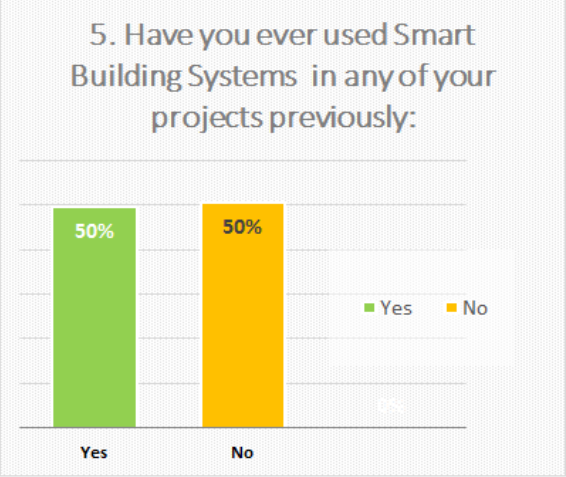


Figure 4.4 SBSs Knowledge Level **Figure 4.5** Use of SBSs

The questions no. 4 and 5 in figures 4.4 and 4.5 shows that, only 22% of the participants have a high level of knowledge about smart buildings, approximately half of the participants with a percentage of 65% responded that they know about smart building systems but not in high level, with 50% of them used smart building systems previously in their projects, while 12% said they have low knowledge about smart building systems, and 50% also haven't use it in any of their projects previously.

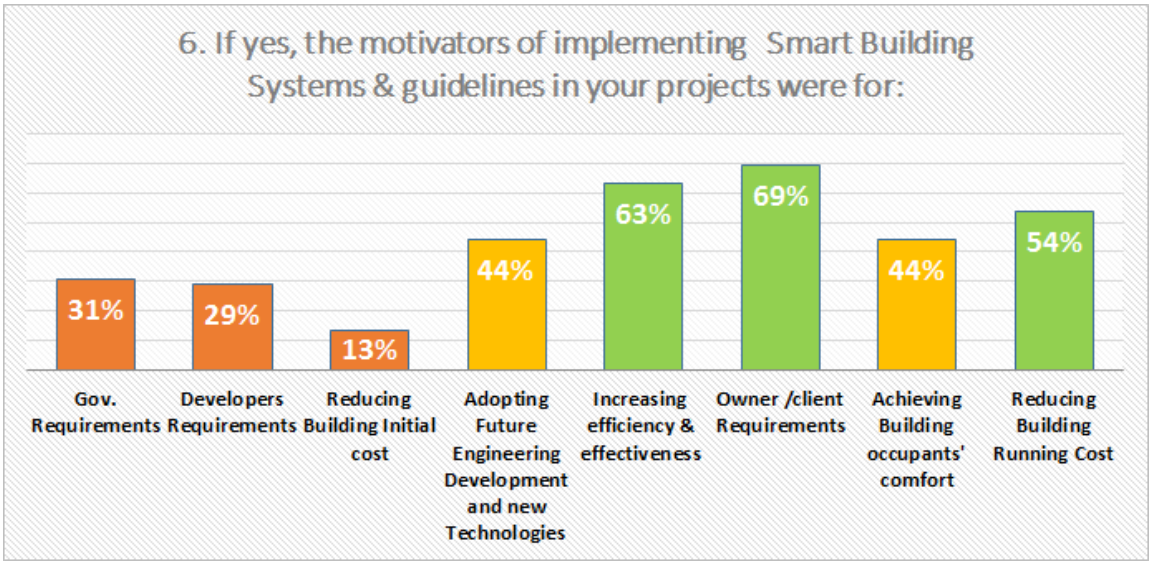


Figure 4.6 Implementation Motivators

Question no. 6 was a multiple selection show that the main motivator behind using smart building systems in projects was due to the building's owners requirements with 69% of the total participant's response. The next main motivator, with 63%, was increasing efficiency and effectiveness in building operations and systems. The third motivator was to reduce running building cost with 54%, also more than 40% selected achieving building occupants comfort and adopting future engineering development and new technologies, 30% approximately was selected as governmental and developer requirements, while reducing building initial cost was the lowest percentage with 13%.

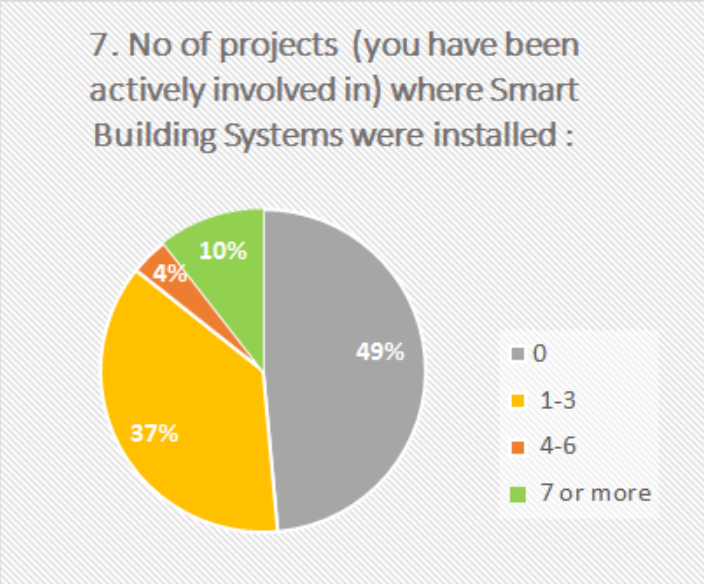


Figure 4.7 No. of Applied Projects with SBSs usage

Question no. 7 shows the number of projects where participants were actively involved in and smart building systems were installed, the response to this question indicated that 49% of the participants didn't work in any project installed with smart building systems, while 10% worked with 7 projects or more, 37% worked in (1 to 3) projects, and 4% responded that they have worked in (4 to 6) projects installed with SBS.

Section-2 Conclusion:

The second Section questions show that approximately half of the participants have good idea about SBS and used it in their projects and the main motivators to use SBS was owner requirements, increasing efficiency and effectiveness and reducing building running cost.

4.2.3. Section Three: Significance of Smart Building Guidelines

(Question from 8 to 11)

From the section subject, it will go through the Significance of Smart Building Guidelines and responsibilities' related.

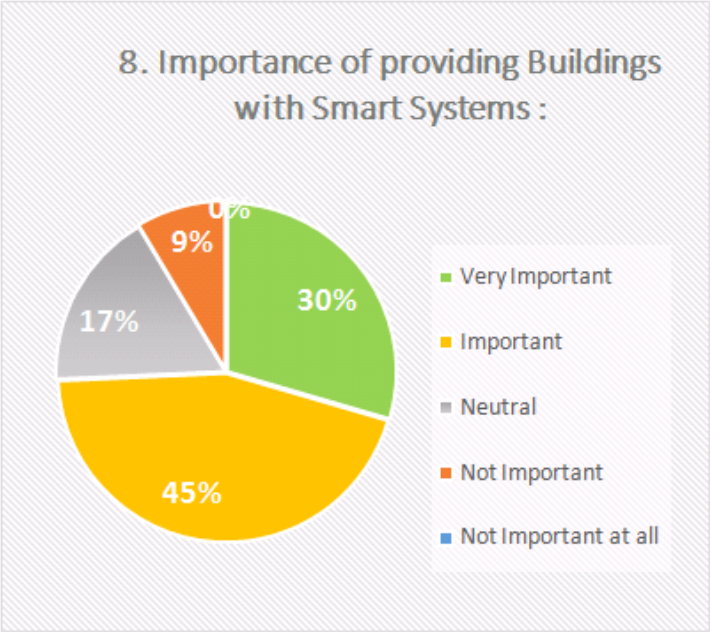


Figure 4.8 Importance of Providing Buildings with SBSs

Question no.8 shows that, 30% of participants said that it's very important to provide buildings with smart systems, and 45% also said that it is important, while 17% indicated as average importance, and 9% as not important.

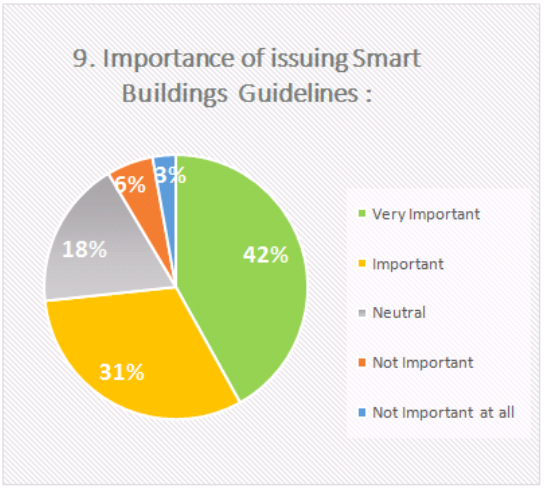


Figure 4.9 Importance of Issuing SB Guidelines

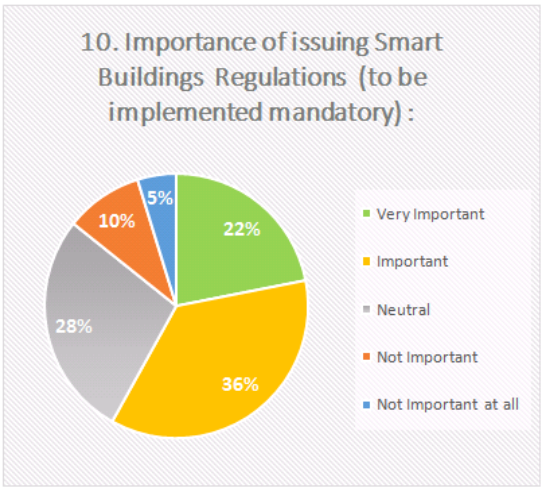


Figure 4.10 Importance of Issuing SB Regulations

Question no.9 shows the response results for the importance of issuing smart building guidelines as more than 70% said that it is important, and 18% replied average importance, while only 6% indicated that it's not important, and 3% not important at all.

Question no.10 gives the responses to the importance of issuing smart building regulations, to be implemented mandatory, only 22% said that it is very important, 36% said it is important, and 28% of responses are average importance, with a total of 86% indicated that it's important to issue regulations. Only 15% indicated that it is not important.

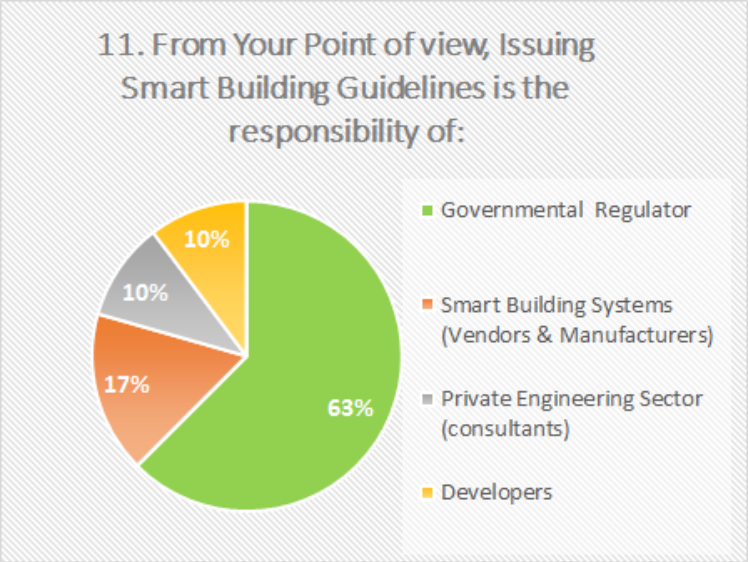


Figure 4.11 Responsibility of Issuing SB Guidelines

Question no.11 shows that, the majority believes that it's the governmental regulator responsibility to issue smart building guidelines, where equal responses of 10% said that's it's the responsibility of developers and consultants, but 17% are convinced that it is the responsibility of smart building systems' vendors .

Section-3 Conclusion:

In general the Third Section questions response show that majority of participants' believe that smart building implementation is important, that require guideline and regulations.

4.2.4. Section Four: Smart Building Guidelines Implementation and phases

(Question from 12 to 15)

Aim of this section is to provide a clear picture for Smart Building Guidelines Implementation and phases in order to identify the priorities, and the stakeholders' requirement for smart building systems and building types.

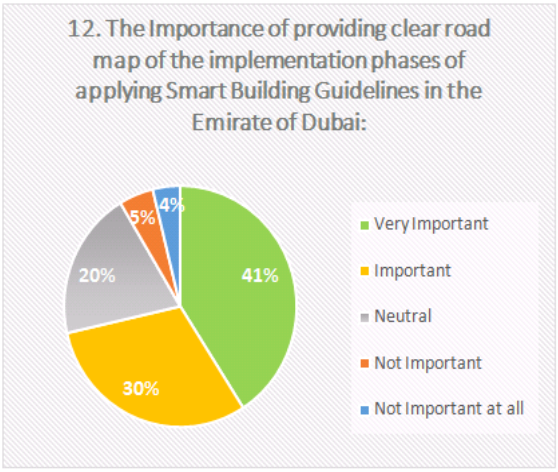


Figure 4.12 Importance of providing Clear road map guidelines

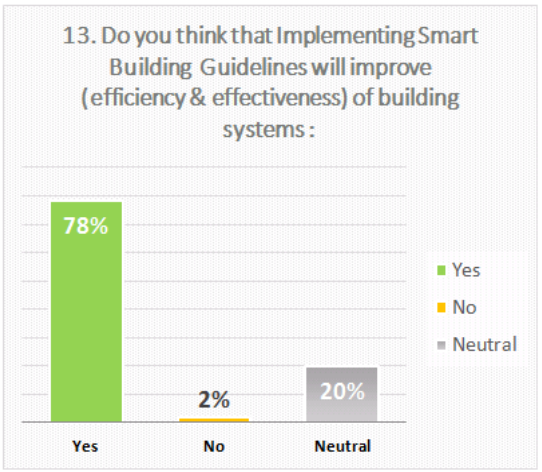


Figure 4.13 Implementing Smart Building will improve Systems' (efficiency and effectiveness)

Question no.12 in figure 4.12 shows the responses to the importance of providing a clear roadmap for the implementation phases of applying smart building guidelines in the Emirate of Dubai, where 41% and 30% of responses were very important or important, respectively, with a 20% average important, 5% said that it's not important to issue a road map, 4% said that it's not important at all.

From the reply of question no.13, 78% agreed that implementing smart building guidelines will improve efficiency and effectiveness of building systems, only 2% didn't agree on the previous statement, and the rest 2% indicated that they have no opinion.

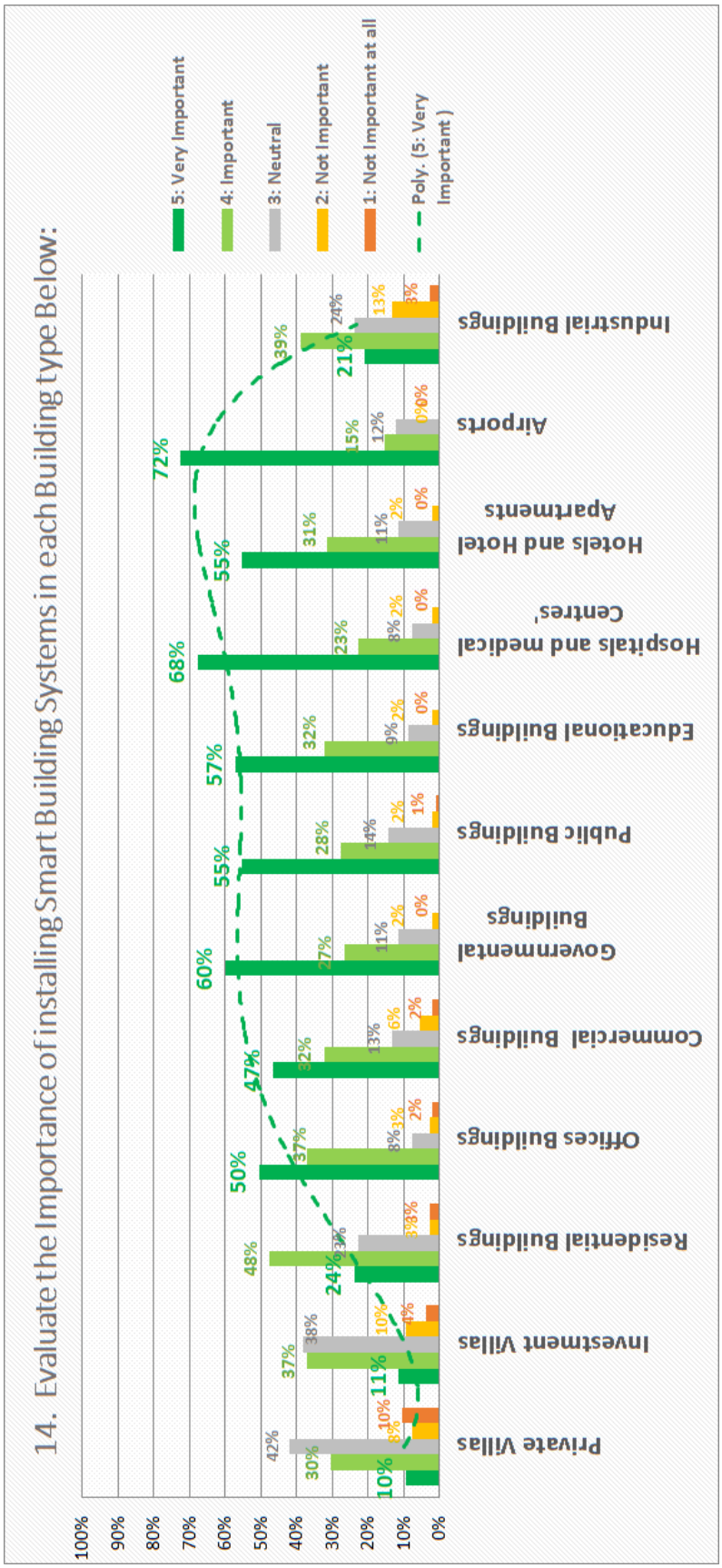


Figure 4.14 Importance of Installing SBS in Each Building Type/Usage

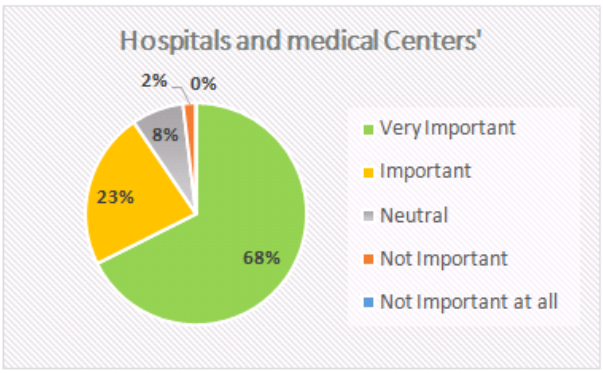
Question no.14 is one of the core questions in the survey, as it shows the participant response of evaluating the importance of installing smart building systems in each building type or usage. As shown in above figure 4.14, the trend line shows the majority selected Airports (72%), Hospitals (68%), Governmental (60%), Hotels (55%) and Public buildings (55%), respectively as per the selection, these are the most important building types to be installed with smart building systems. While, only 10% selected private villas to be installed with smart systems, and 11% for investment villas.

The following building with the indicated percentage, were selected to be the most important building types/usages to be installed with smart building systems:

- 57% Educational buildings
- 50% Offices buildings
- 47% Commercial buildings
- 24% Residential buildings
- 21% Industrial buildings

The highest percentage 13% evaluated the importance of installing smart building systems in industrial building as not important at all, also 10% evaluated private villas the same, these results seems to be logic regarding the usage of industrial buildings as it don't actually require smart systems, and private villas should be left to the owners personal choice.

Following is detailed analysis of **Question no. 14**, Importance of Installing SBS in Each Building Type / Usage:



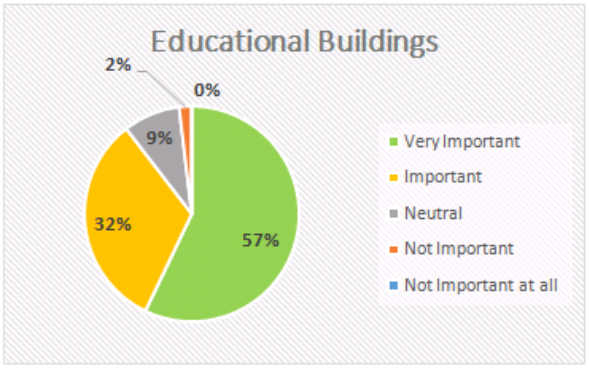
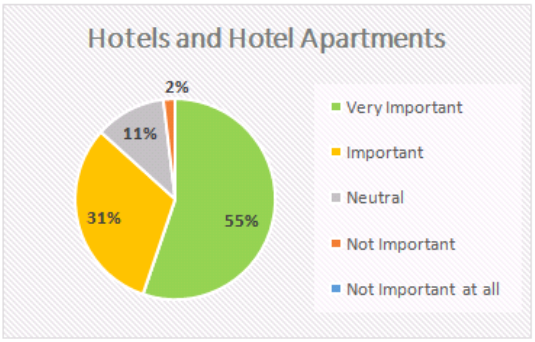


Figure 4.15 Importance of Installing SBSs in Hospitals, Medical Centres' And in Educational Buildings

- The evaluation for **Hospitals and medical Centres',** total of 91% said that it is important to install SBS, which takes the highest degree of importance among all buildings types and usages.
- The evaluation for **Educational Buildings,** total of 89% said that it is important to install SBS, which also takes the second highest degree of importance after hospitals.



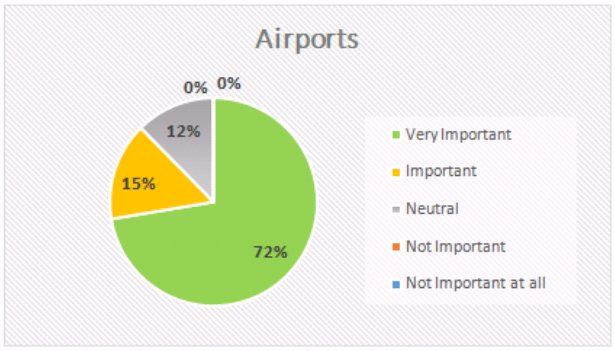


Figure 4.16 Importance of Installing SBSs in Hotels, Hotel Apartments' And in Airports

- The evaluation for **Hotels and Hotel Apartments,** total of 86% said that it is important to install SBS, which is also one of highest degree of importance, the nature of the hotel usage force it to be smart to provide comfort and energy saving needed due to the heavy usage of hotels.

- The evaluation for **Airports,** total of 87% said that it is important to install SBS and its logic that airports should be smart due the very important and due to type of such large scale usage, as airports was the first building types to apply smart building features in many ways.

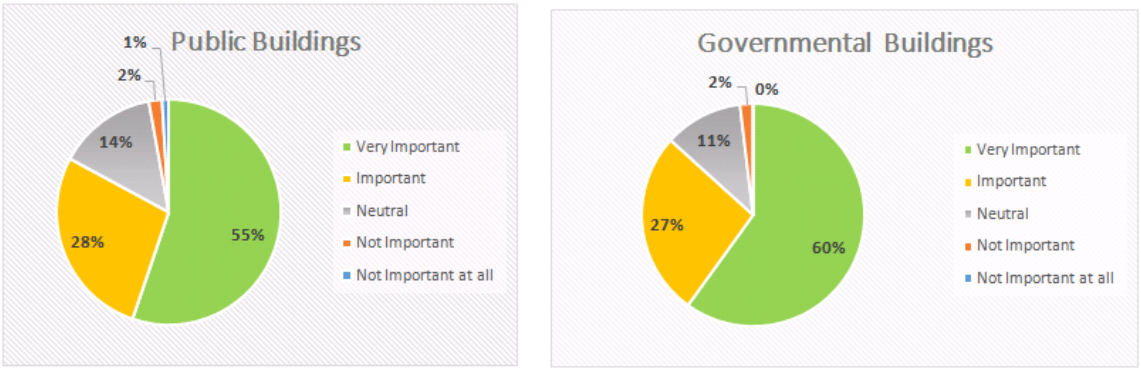


Figure 4.17 Importance of Installing SBSs in Public Buildings

And in Governmental Buildings

- The evaluation for **Public Buildings,** total of 83% said that it is important to install SBS, which is comes in the third level of importance after offices and governmental buildings.
- The evaluation for **Governmental Buildings**, total of 87% said that it is important to install SBS, which is same level of importance with offices buildings.

Public and governmental building in terms of implementation should be the first to implement smart building systems, as these buildings represent the city government and the row model for the rest of building stakeholders.

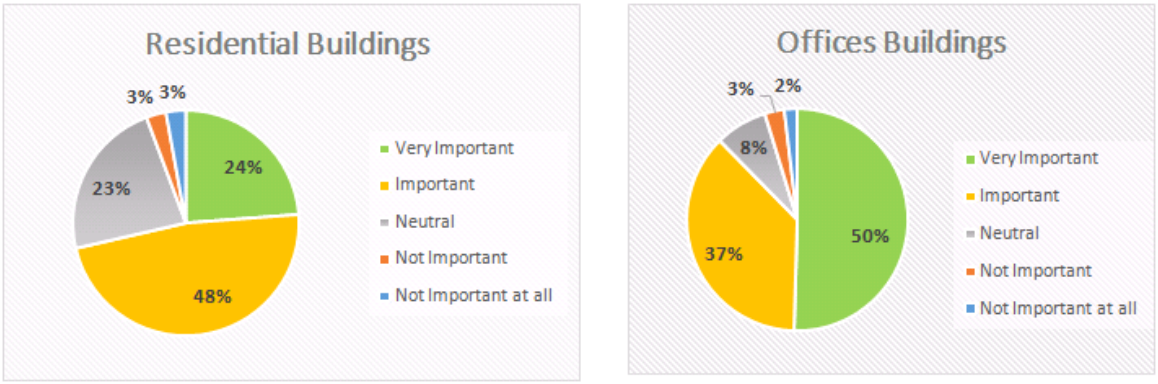


Figure 4.18 Importance of Installing SBSs in Residential Buildings

And in Offices Buildings

- The evaluation for **Residential Buildings,** total of 72% said that it is important to install SBS which is a higher percentage compared to the results of the villas, as noted in residential buildings the percentage of importance have dropped down, compared to offices buildings where some hesitation and maybe cost factors effected the results, as owners and tenants is a major players related to residential.
- The evaluation for **Offices Buildings,** total of 87% said that it is important to install SBS, which is also a higher percentage compared to the results of the villas, commercial, industrial and residential buildings.

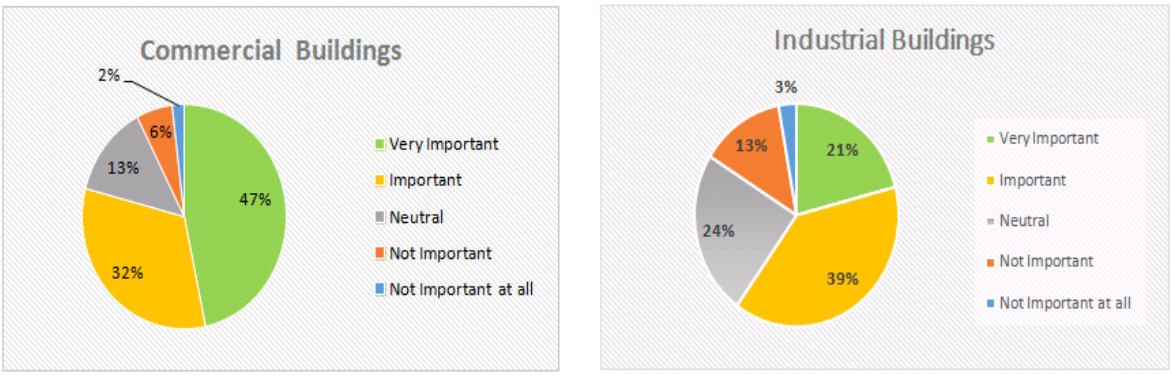


Figure 4.19 Importance of Installing SBSs in Commercial Buildings

And in Industrial Buildings

- The evaluation for **Commercial Buildings,** total of 79% said that it is important to install SBS, which is also a higher percentage compared to the results of the villas, and residential buildings.
- The evaluation for **Industrial Buildings,** total of 60% said that it is important to install SBS, which is obviously lower percentage compared to the results of above buildings types and usages.

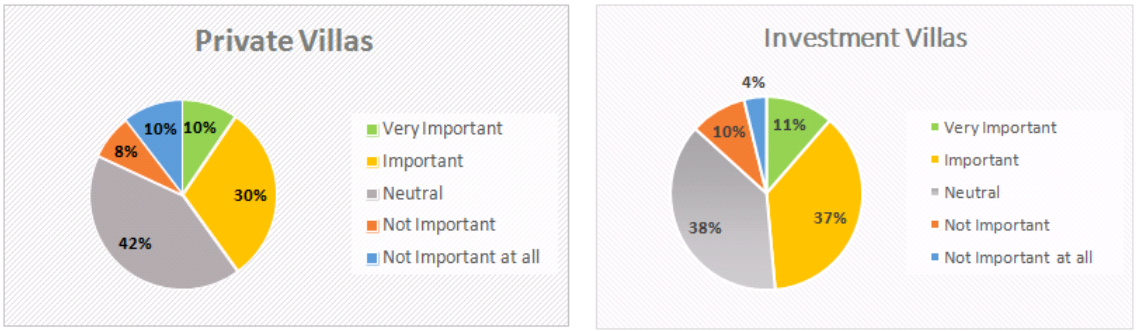


Figure 4.20 Importance of Installing SBSs in Private Villas

And in Investment Villas

- The evaluation for **Private Villa,** total of 40% said that it is important to install SBS, the lowest level of importance of all buildings types and usages
- The evaluation for **Investment Villas**, total of 48% said that it is important to install SBS, one of the two lowest levels of importance of all buildings types and usages.

Villas could be left to be optional selection, left to the personal choice, and this will not conflict with the owners and city resident's satisfaction level.

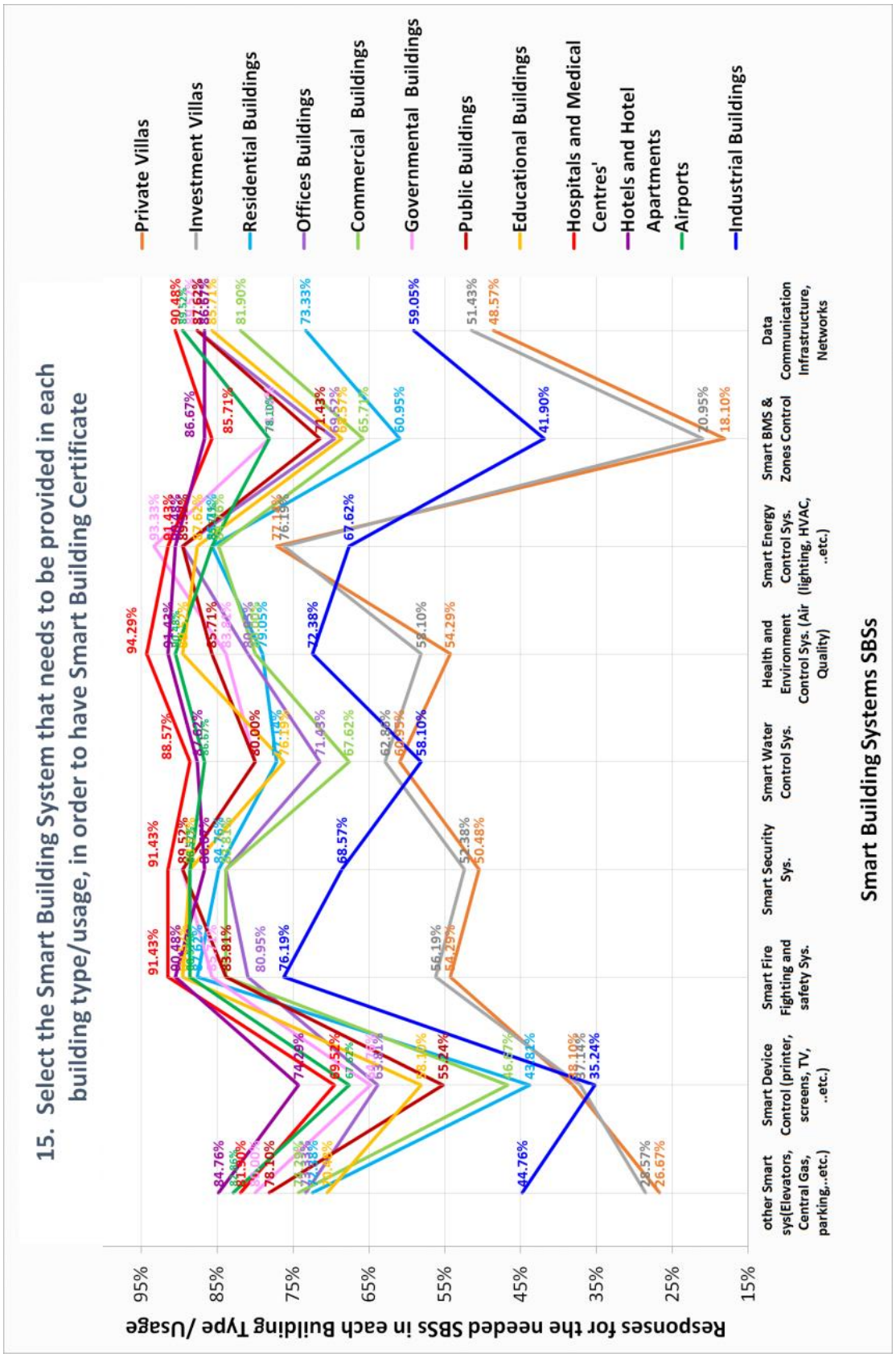
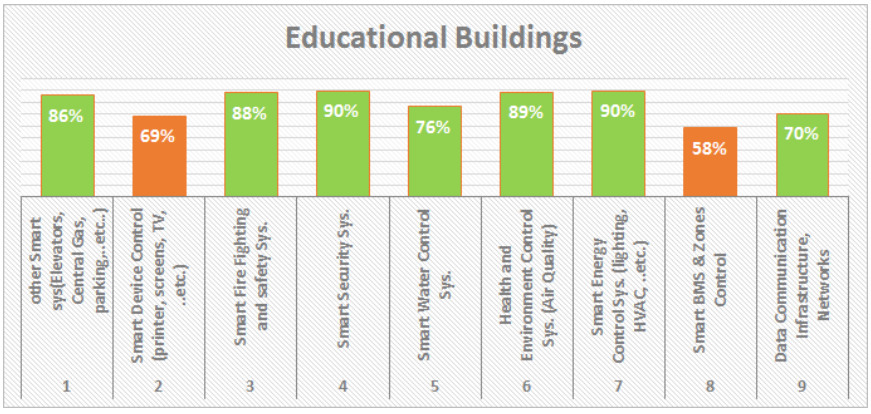


Figure 4.21 Evaluation for The SBSs that needs to be provided in each Building Type/Usage

Question no.15 is a core and a very important question in the survey. Evaluation for The SBS that needs to be provided in each Building Type/Usage, as shown in figure 4.21. The hospitals, medical centres', hotels, hotel apartments' and airports, results show that these types should be provided with smart building systems in order to have a smart building certificate. Industrial building and villas were not selected to be provided with most smart building systems. Regarding the smart building systems selected in order to have smart building certificate, the most selected systems were clearly the smart energy, security, and fire fighting systems for most of the building types/usages. Smart BMS and smart devices were not preferred to for most f building types/usages.

In this question, each building type results were analysed separately, detailed in the following:

(a)



(b)

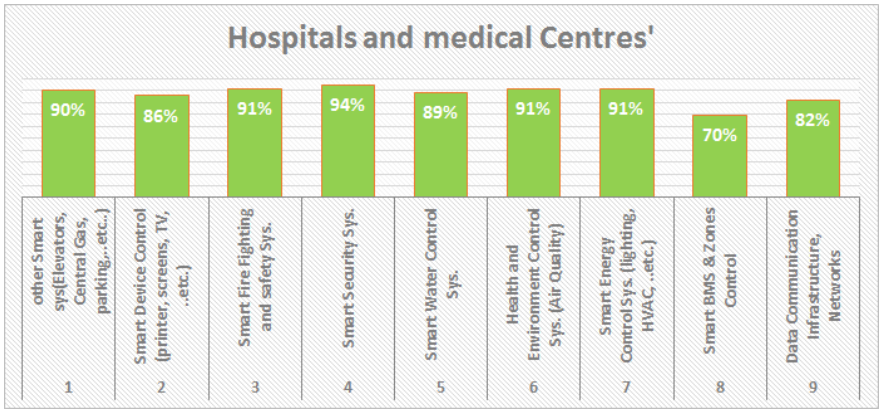
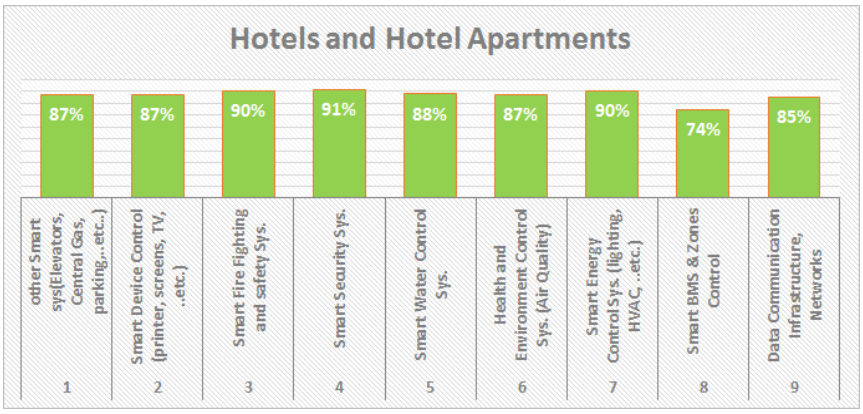


Figure 4.22 SBSs that needs to be provided in (a) Educational Buildings, (b) Hospital and Medical Centers' to have SB Certificate

From figure above, hospitals and medical centres' clearly takes the priority to be installed with BMS and smart devices, where only 59% selected BMS to be installed in educational buildings.

- The evaluation for the SBSs that needs to be provided in **Educational Buildings:**
  - 90% selected ***Smart Energy Control (Lighting & HVAC)*** (the highest percentage)
  - 90% selected ***Smart Security Sys.***
  - 89% selected Health & Environment Control Sys. (Air Quality)
  - 86% selected other Smart Sys. (Elevators, Central Gas, Parking, etc.)
  - 76% selected Smart Water Control Sys.
  - 70% selected Data Communication Infrastructure, Networks
  - 69% selected Smart Device Control (printer, screens, TV, etc.)
  - 58% selected Smart BMS & Zones Control
- The evaluation for the SBSs that needs to be provided in **Hospitals & Medical Centres:**
  - 94% selected ***Smart Security Sys.*** (the highest percentage)
  - 91% selected ***Smart Energy Control (Lighting & HVAC)***
  - 91% selected ***Smart Fire Fighting & Safety Sys***.
  - 91% selected ***Health & Environment Control Sys. (Air Quality)***
  - 90% selected other ***Smart Sys. (Elevators, Central Gas, Parking, etc.)***
  - 89% selected ***Smart Water Control Sys.***
  - 82% selected ***Data Communication Infrastructure, Networks***
  - 86% selected ***Smart Device Control (printer, screens, TV, etc.)***
  - 70% selected ***Smart BMS & Zones Control***

(a)



(b)

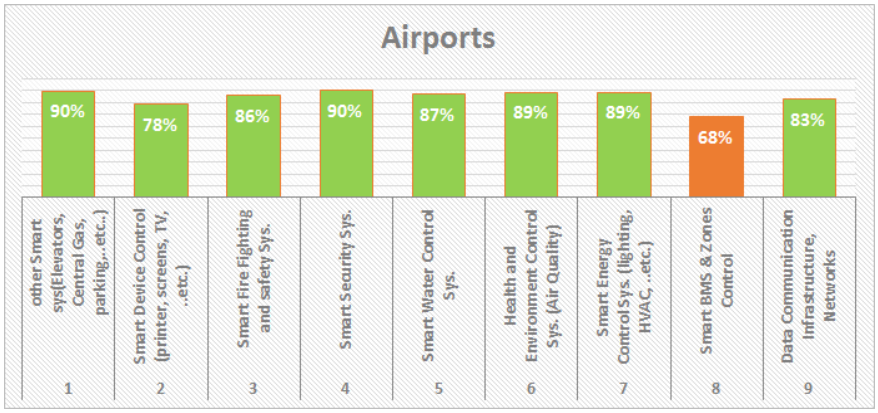


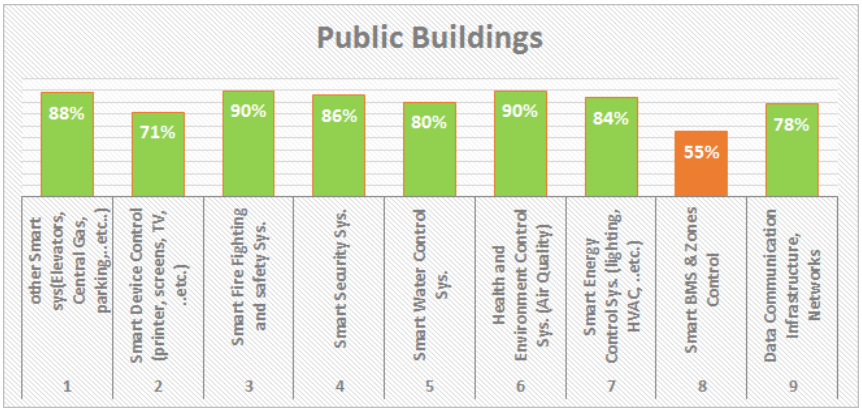
Figure 4.23 SBSs that needs to be provided in (a) Hotels, Hotel Apartments' and (b)Airports, to have SB Certificate

- The evaluation for the SBSs that needs to be provided in **Hotels & Hotel Apartments:**
  - 91% selected ***Smart Security Sys***. (the highest percentage)
  - 90% selected ***Smart Energy Control (Lighting & HVAC)***
  - 90% selected ***Smart Fire Fighting & Safety Sys.***
  - 88% selected ***Smart Water Control Sys.***
  - 87% selected ***Health & Environment Control Sys. (Air Quality)***
  - 87% selected ***other Smart Sys. (Elevators, Central Gas, Parking, etc.)***
  - 87% selected ***Smart Device Control (printer, screens, TV, etc.)***
  - 85% selected ***Data Communication Infrastructure, Networks***

- 74% selected ***Smart BMS & Zones Control***

- The evaluation for the SBSs that needs to be provided in **Airports**:
  - 90% selected ***Smart Security Sys.***
  - 90% selected ***other Smart Sys. (Elevators, Central Gas, Parking, etc.)***
  - 89% selected ***Health & Environment Control Sys. (Air Quality***)
  - 89% selected ***Smart Energy Control (Lighting and HVAC)***
  - 87% selected Smart Water Control Sys.
  - 86% selected Smart Fire Fighting and safety Sys.
  - 83% selected Data Communication Infrastructure, Networks
  - 78% selected Smart Device Control (printer, screens, TV, etc.)
  - 68% selected Smart BMS & Zones Control

(a)



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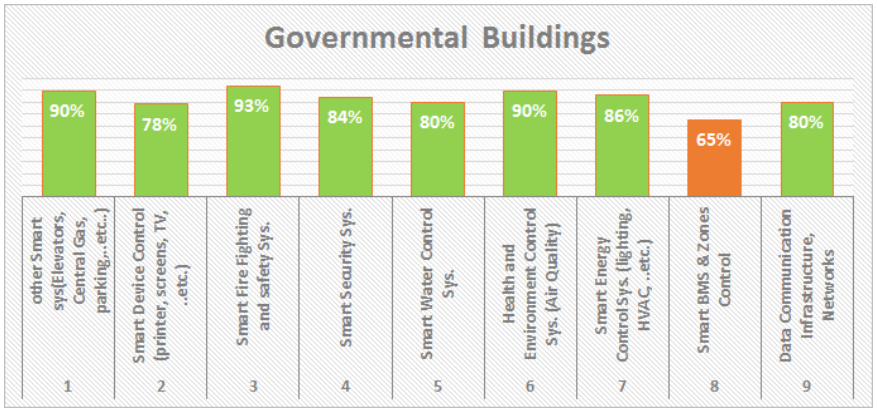
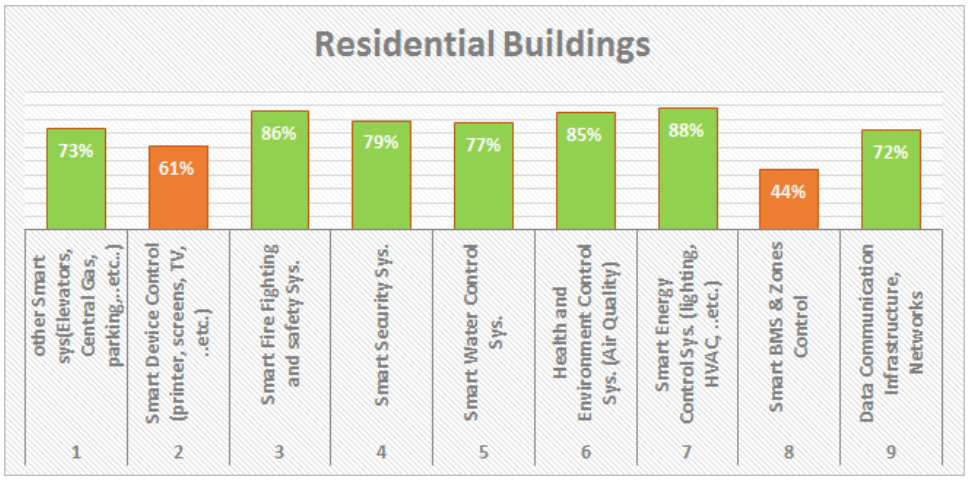


Figure 4.24 SBSs that needs to be provided in (a) Public and (b) Governmental Buildings to have SB Certificate

- The evaluation for the SBSs that needs to be provided in **Public Buildings**:
  - 90% selected Smart Fire Fighting and safety Sys. (the highest percentage)
  - 90% selected Health and Environment Control Sys. (Air Quality)
  - 88% selected other Smart Sys. (Elevators, Central Gas, Parking, etc.)
  - 86% selected Smart Security Sys.
  - 84% selected smart Energy control (lighting and HVAC)
  - 80% selected Smart Water Control Sys.
  - 78% selected Data Communication Infrastructure, Networks
  - 71% selected Smart Device Control (printer, screens, TV, etc.)
  - 55% selected Smart BMS & Zones Control
- The evaluation for the SBSs that needs to be provided in **Governmental Buildings**:
  - 93% selected Smart Fire Fighting and safety Sys. (the highest percentage)
  - 90% selected Health and Environment Control Sys. (Air Quality)
  - 90% selected other Smart Sys. (Elevators, Central Gas, Parking, etc.)
  - 86% selected smart energy control (lighting and HVAC)
  - 84% selected Smart Security Sys.
  - 80% selected Smart Water Control Sys.
  - 80% selected Data Communication Infrastructure, Networks
  - 78% selected Smart Device Control (printer, screens, TV, etc.)
  - 65% selected Smart BMS & Zones Control

  As noticed in figure above, that only smart BMS is not preferred to be provided in public and governmental buildings to have smart building certificate.

(a)



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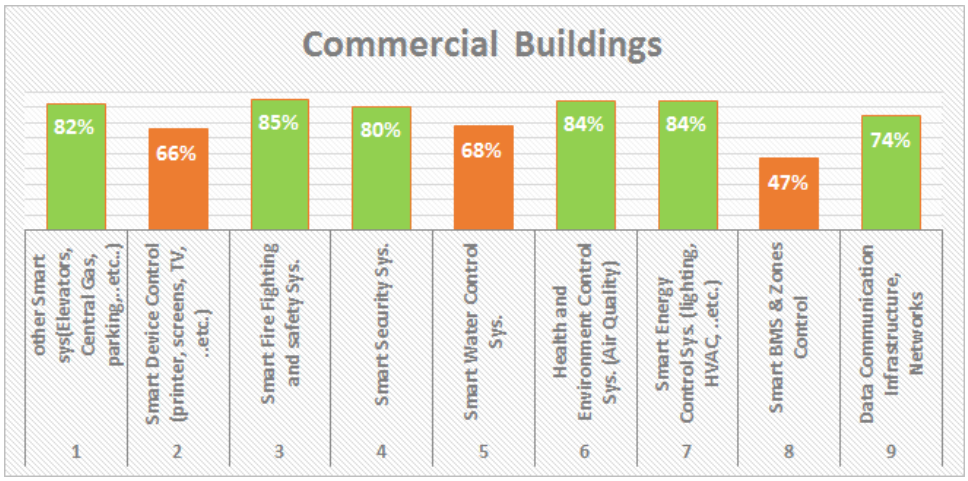


Figure 4.25 SBSs that needs to be provided in (a) Residential and (b) Commercial Buildings to have SB Certificate

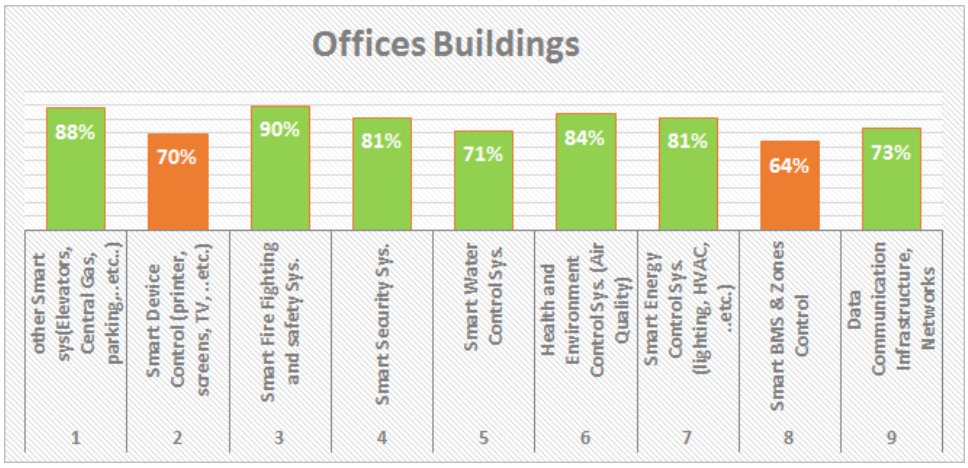
- The evaluation for the SBSs that needs to be provided in **Residential Buildings**:
  - 88% selected ***smart Energy Control (Lighting & HVAC)*** (the highest percentage)
  - 86% selected ***Smart Fire Fighting & Safety Sys.***
  - 85% selected ***Health & Environment Control Sys. (Air Quality)***
  - 79% selected ***Smart Security Sys.***
  - 77% selected ***Smart Water Control Sys.***
  - 73% selected ***other Smart Sys. (Elevators, Central Gas, Parking, etc.)***
  - 72% selected ***Data Communication Infrastructure, Networks***

- 61% selected ***Smart Device Control (printer, screens, TV, etc.)***
- 44% selected ***Smart BMS & Zones Control***

- The evaluation for the SBSs that needs to be provided in **Commercial Buildings**:
  - 85% selected ***Smart Fire Fighting and safety Sys.*** (the highest percentage)
  - 84% selected ***Smart Energy Control (Lighting & HVAC)***
  - 84% selected ***Health and Environment Control Sys. (Air Quality)***
  - 82% selected ***other Smart Sys. (Elevators, Central Gas, Parking, etc.)***
  - 80% selected ***Smart Security Sys***.
  - 74% selected ***Data Communication Infrastructure, Networks***
  - 68% selected ***Smart Water Control Sys.***
  - 66% selected ***Smart Device Control (printer, screens, TV, etc.)***
  - 47% selected ***Smart BMS & Zones Control***

  It is noticed that most of responses ignored smart BMS and smart devices, which give indication that these are not preferred to be provided to have smart building certificate.

(a)



(b)

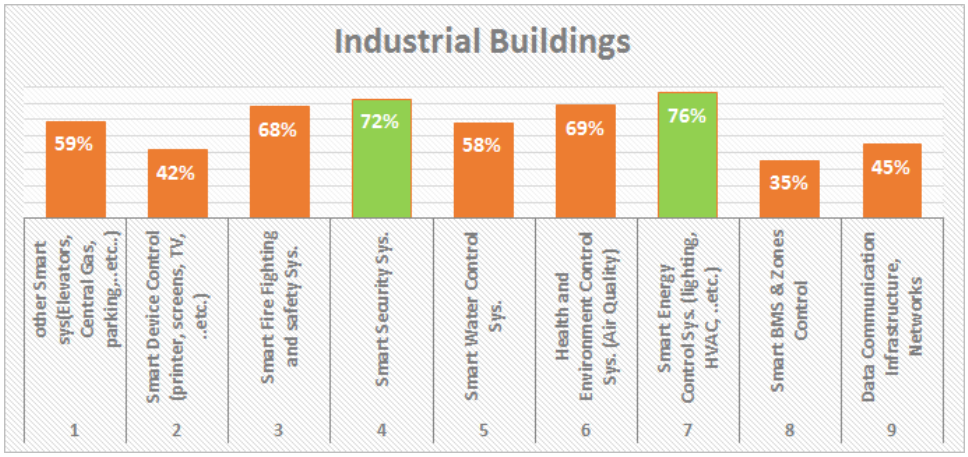


Figure 4.26 SBSs that needs to be provided in (a) Offices and (b) Industrial Buildings to have SB Certificate

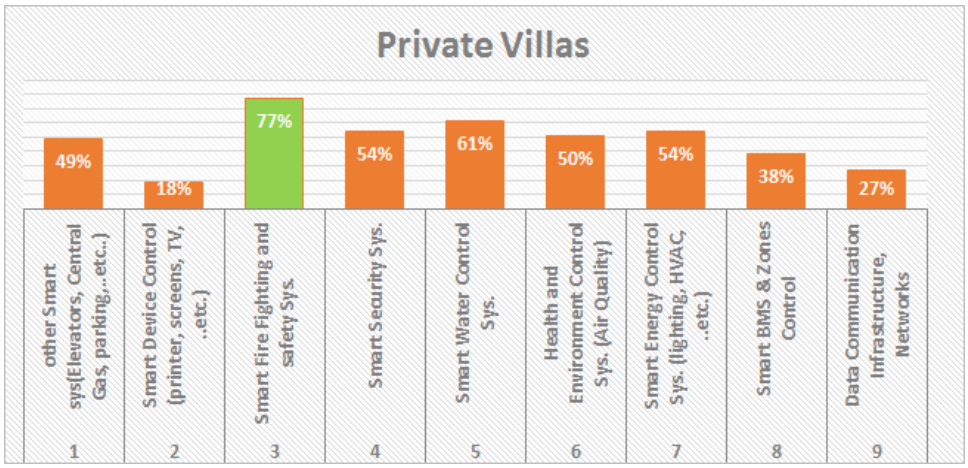
- The evaluation for the SBSs that needs to be provided in **Offices Buildings**:
  - 90% selected ***Smart Fire Fighting & safety Sys.*** (the highest percentage)
  - 88% selected ***other Smart Sys. (Elevators, Central Gas, Parking, etc.)***
  - 84% selected ***Health & Environment Control Sys. (Air Quality)***
  - 81% selected ***Smart Security Sys.***
  - 81% selected ***Smart Energy Control (Lighting & HVAC)***
  - 73% selected ***Data Communication Infrastructure, Networks***
  - 71% selected ***Smart Water Control Sys.***
  - 70% selected ***Smart Device Control (printer, screens, TV, etc.)***

- 64% selected ***Smart BMS & Zones Control***

- The evaluation for the SBSs that needs to be provided in **Industrial Buildings**:
  - 76% selected ***Smart Energy Control (Lighting & HVAC)*** (the highest percentage)
  - 72% selected ***Smart Security Sys***.
  - 69% selected ***Health & Environment Control Sys. (Air Quality)***
  - 68% selected ***Smart Fire Fighting and safety Sys.***
  - 59% selected ***other Smart Sys. (Elevators, Central Gas, Parking, etc.)***
  - 58% selected ***Smart Water Control Sys***.
  - 45% selected ***Data Communication Infrastructure, Networks***
  - 42% selected ***Smart Device Control (printer, screens, TV, etc.)***
  - 35% selected ***Smart BMS & Zones Control***

It is noticed that most of responses was smart energy and security systems, which give indication that industrial buildings is not preferred to be smart by most of the applicants.

(a)



(b)

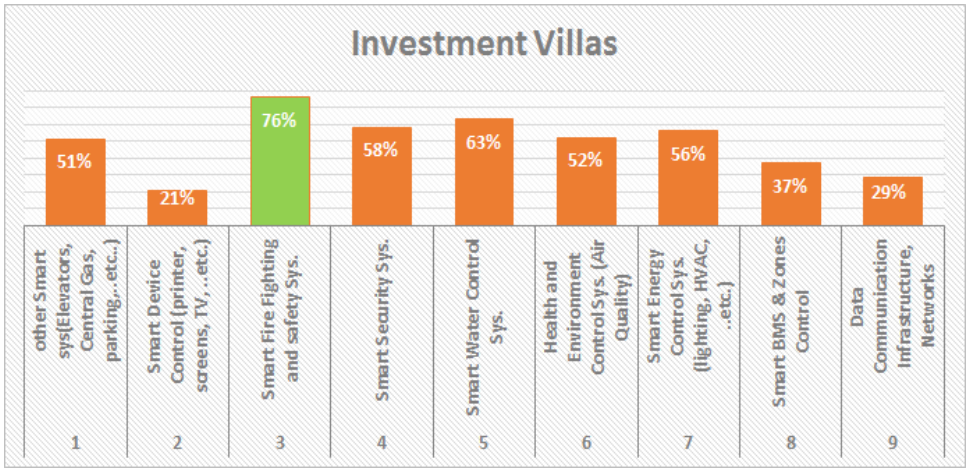


Figure 4.27 SBSs that needs to be provided in (a) Private and (b)Investment Villas to have SB Certificate

- The evaluation for the SBSs that needs to be provided in **Private Villas**:
  - 77% selected ***Smart Fire Fighting & Safety Sys.*** (the highest percentage)
  - 61% selected ***Smart Water Control Sys.***
  - 54% selected ***Smart Energy Control (Lighting & HVAC)***
  - 54% selected ***Smart Security Sys.***
  - 50% selected ***Health and Environment Control Sys. (Air Quality)***
  - 49% selected ***other Smart Sys. (Elevators, Central Gas, Parking, etc.)***
  - 38% selected ***Smart BMS & Zones Control***
  - 27% selected ***Data Communication Infrastructure, Networks***

- 18% selected Smart Device Control (printer, screens, TV, etc.)

- The evaluation for the SBSs that needs to be provided in **Investment Villas**:
  - 76% selected ***Smart Fire Fighting and Safety Sys.*** (the highest percentage)
  - 63% selected ***Smart Water Control Sys.***
  - 58% selected ***Smart Security Sys.***
  - 56% selected ***Smart Energy Control (Lighting & HVAC)***
  - 52% selected ***Health and Environment Control Sys. (Air Quality)***
  - 51% selected ***other Smart Sys. (Elevators, Central Gas, Parking, etc.)***
  - 37% selected ***Smart BMS & Zones Control***
  - 29% selected ***Data Communication Infrastructure, Networks***
  - 21% selected ***Smart Device Control (printer, screens, TV, etc.)***

It is noticed that most of responses was fighting and safety systems, which give indication that villas is not preferred to be smart by most of the applicants.

In general, as shown in Figure 4.28, the average percentage selected for each smart building system was:

- 85% selected ***Smart Fire Fighting and safety Sys.***
- 81% selected ***Smart Energy Control (Lighting & HVAC)***
- 80% selected ***Smart Security Sys.***
- 80% selected ***Health and Environment Control Sys. (Air Quality)***
- 78% selected ***other Smart Sys. (Elevators, Central Gas, Parking, etc.)***
- 75% selected ***Smart Water Control Sys.***
- 67% selected ***Data Communication Infrastructure, Networks***
- 62% selected ***Smart Device Control (printer, screens, TV, etc.)***
- 55% selected ***Smart BMS & Zones Control***

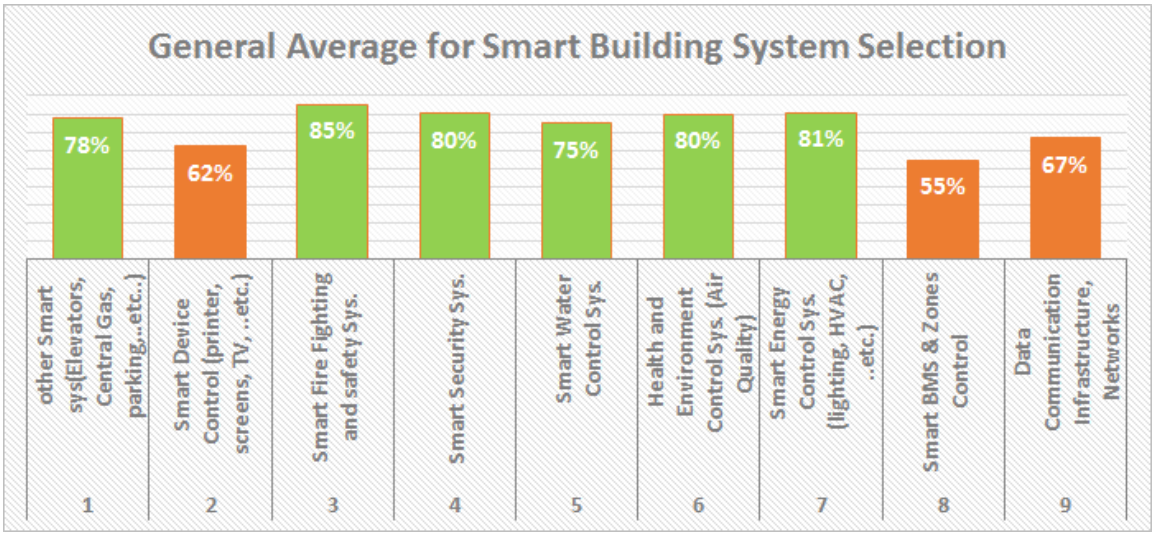


Figure 4.28 General Average for each SBSs selected by participants to have SB Certificate

This analysis indicated the priority for each system where Smart Fire Fighting and safety Systems takes the first priority to have smart building certificate, also with a high priority comes the smart energy systems (HVAC, Lighting), smart security systems comes as a third priority, it noticed that Health and Environment Control systems were selected by 80% of the participants which gives these systems high priority furthermore. BMS is not preferred to be provided in buildings by more than 50% of the responses.

4.2.4. Section Five: Cost and Impact of Smart Buildings Systems

(Question from 16 to 26)

This section is the last part of the survey, the aim of it is to analyse cost from the participants' point of view, and identifying the main impacts of implementing smart building systems.

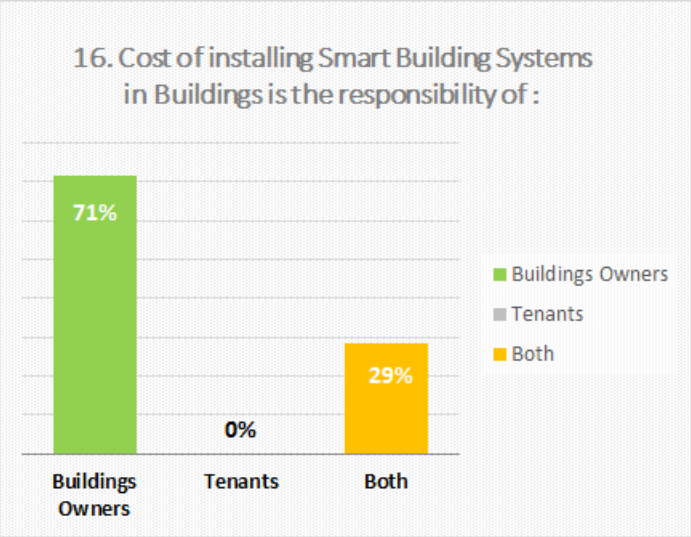


Figure 4.29 Cost of Installing Smart Building Systems- Responsibility

As shown in above figure, question no.16 is determining the responsibility of the installing cost of smart building systems where 71% said that it's Buildings Owners responsibility, while 29% said it's a shared responsibility between owners and tenants.

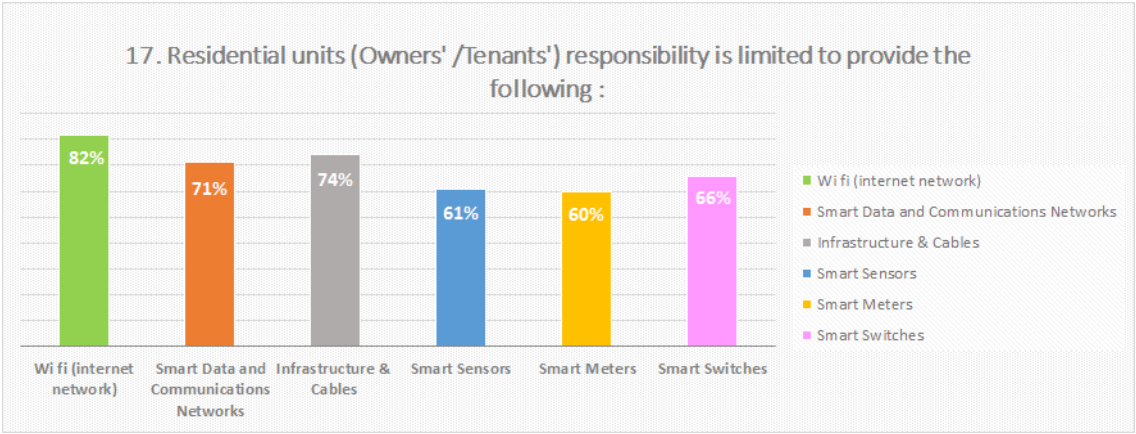


Figure 4.30 Residential units (Owners' /Tenants') responsibility

As shown in figure 4.30, question no.17 is a multiple choice selection, determining the Residential units (Owners'/ Tenants') responsibility of providing some features related to implementing smart building systems as follows:

- 82% selected Wi Fi (internet network)
- 74% selected Infrastructure & Cables

- 71% selected Smart Data and Communications Networks
- 61% selected Smart Sensors
- 66% selected Smart Switches
- 60% selected Smart Meters

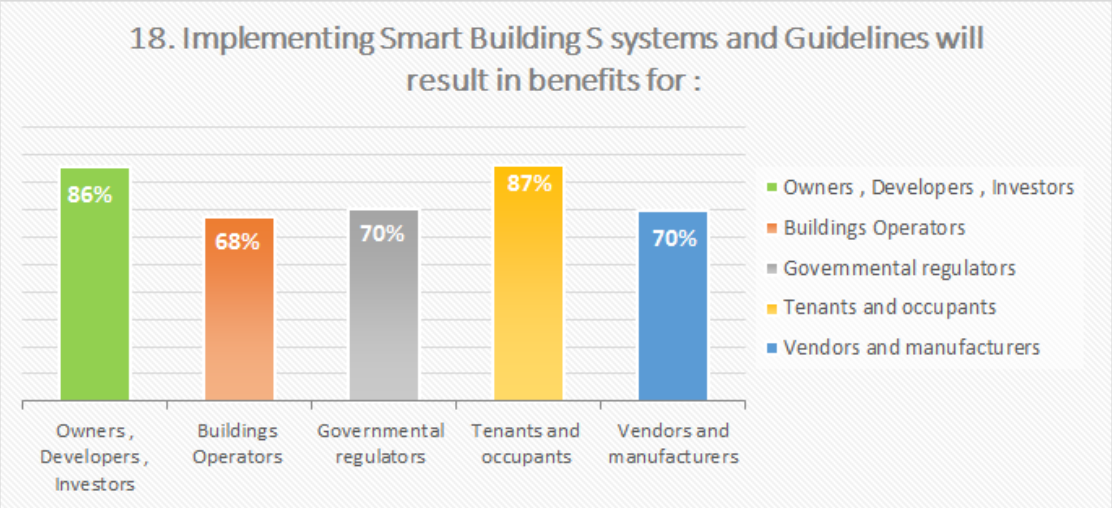


Figure 4.31 Beneficiaries of Implementing SBS and Guidelines

Question no. 18 response shows that, Beneficiaries of Implementing SBS and Guidelines are rated as following:

- First Beneficiary are Tenants and occupants with 87%
- Second Beneficiary are Owners, Developers, Investors with 86%
- Third Beneficiary are Vendors and manufacturers and Governmental regulators with 70%
- fourth Beneficiary are Buildings Operators with 68%

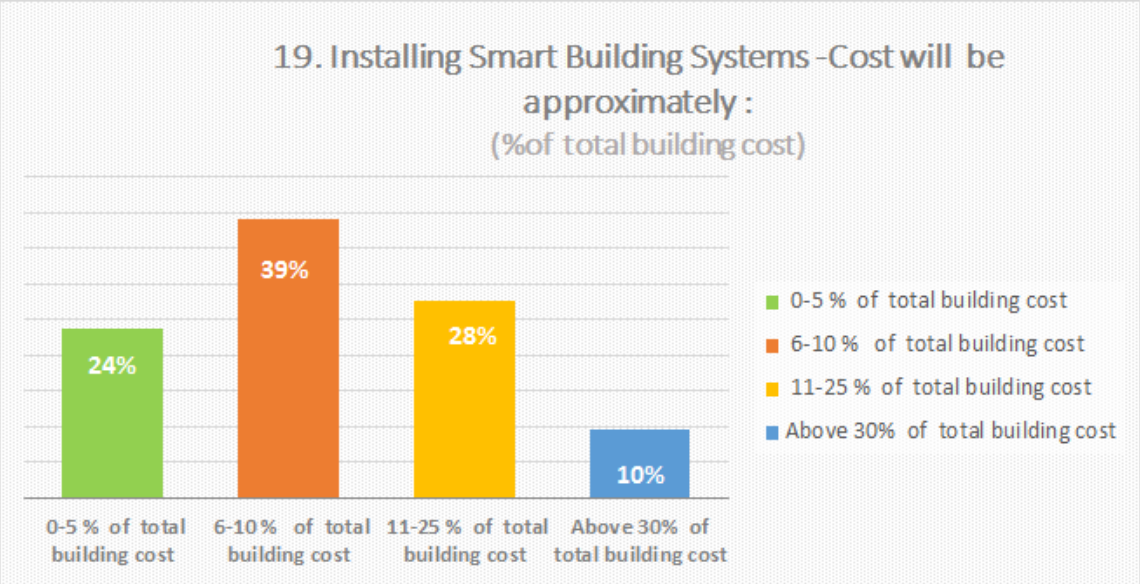


Figure 4.32 Approximate cost of Installing SBS

In question no. 19, the responses shows that most of the participant said that the approximate cost of installing SBS will not exceed 10% of the total building cost, where 24% though it will be less than 5% from total building cost, while 28% said it will be between (11-25%), and 10% indicated that it will be above 30%.

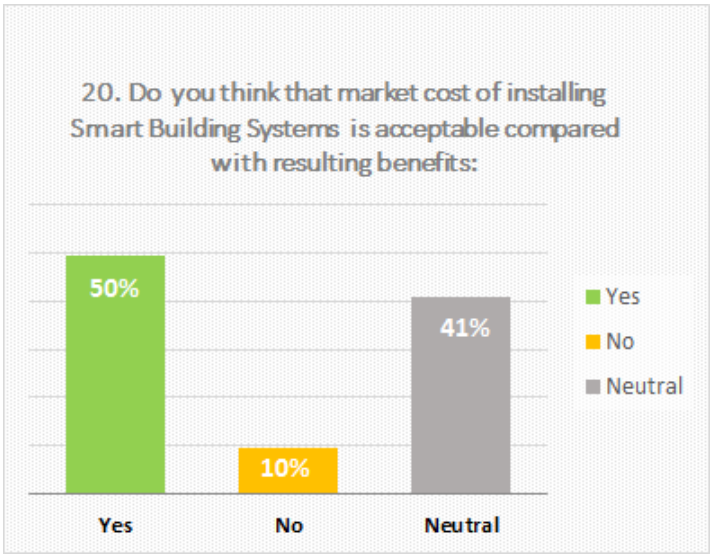


Figure 4.33 SBS Installing Cost Compared with Resulting Benefits

In Question no. 20 in Figure 4.33, half of the participants (50%) answered that the market cost of installing smart building systems is accepted compared with the resulting

benefits, 10% thought that the cost isn't acceptable, while 41% have no opinion, and it could be due to multiple reason, either they are not aware to the benefits of installing of installing smart building systems or they are not aware to cost value.

In general, the following are the last 5 questions related to the impacts of installing smart building systems on some important and future life aspects.

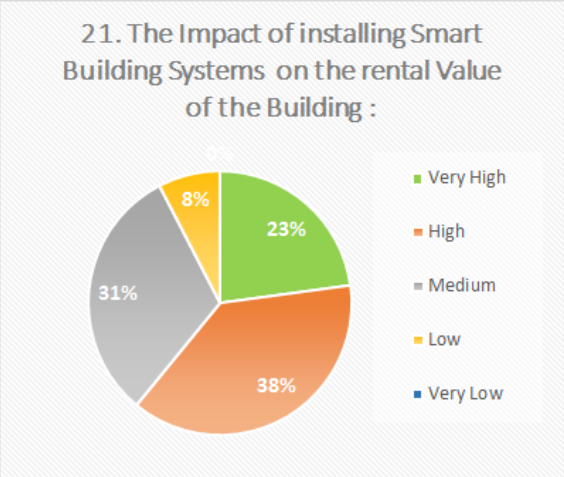


Figure 4.34 Impact Level of Installing SBSs on Rental Value

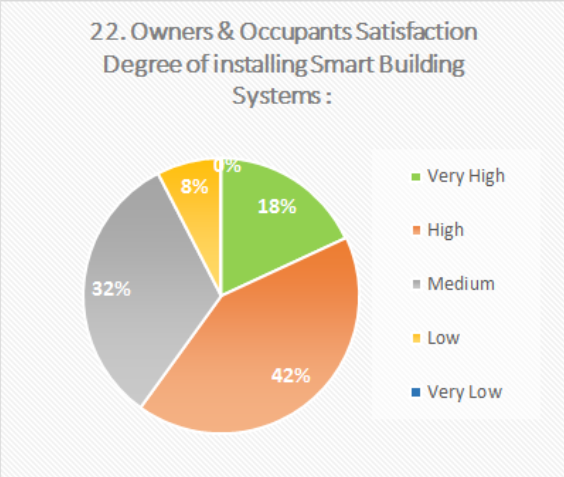


Figure 4.35 Owners & Occupants Satisfaction Degree of Installing SBSs

Question no.21 shows the answers of impact level of installing smart building systems on **Rental Value** as 23% said that it will be very high and 38% said that it will be high; also 31% indicated it will be medium, while only 8% said that it will be low.

Question no.22 shows the answers of owners and occupants' satisfaction degree of installing smart building systems, where 18% said that it will be very high and 42% said that it will be high, also 32% indicated it will be medium, while only 8% said that it will be low.

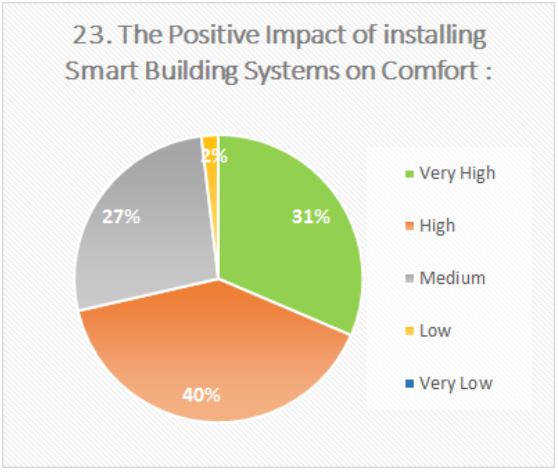


Figure 4.36 Level of the Positive Impact of Installing SBS on Comfort

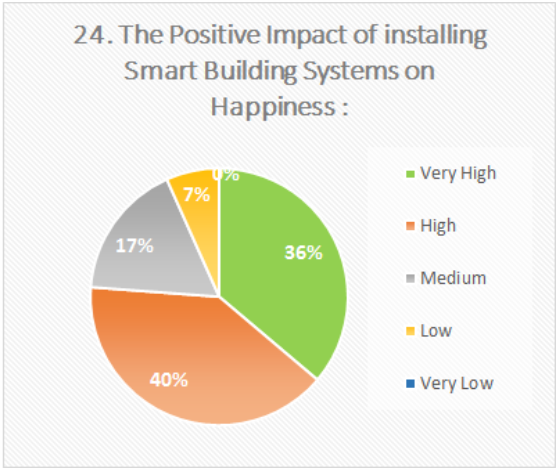


Figure 4.37 Level of the Positive Impact of Installing SBS on Happiness

Question no.23 shows the answers of the positive impact level of installing smart building systems on **Comfort** as 31% said that it will be very high and 40% said that it will be high; 27% indicated it will be medium, while only 2% said that it will be low.

Question no.24 shows the answers of the positive impact level of installing smart building systems on **Happiness** as 36% said that it will be very high and 40% said that it will be high; 17% indicated it will be medium, while only 7% said that it will be low.

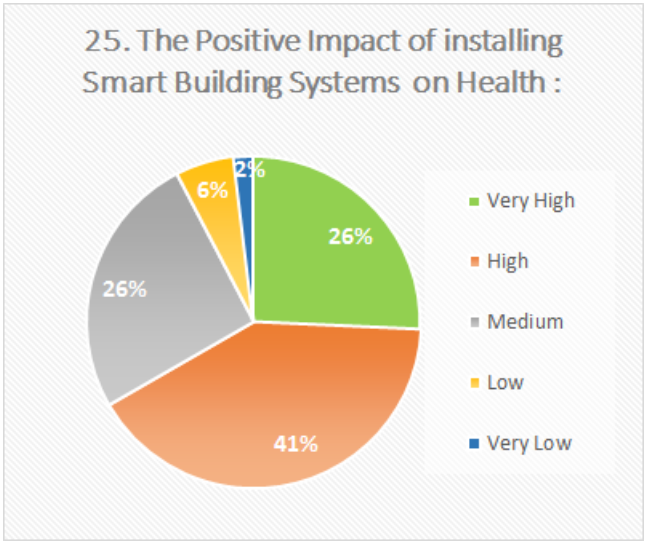


Figure 4.38 Level of the Positive Impact of Installing SBS on Health

Question no.25 in Figure 4.38 shows the answers of the positive impact level of installing smart building systems on **Health** as 26% said that it will be very high and 41% said that it will be high; also 26% indicated it will be medium, while only 6% said that it will be low, and last 2% said it will be very low.

4.2.5. Section Conclusion

Smart Building and the Smart Building Implementation Framework SBIF will be a major step towards the future of construction and open data vision, as smart buildings shapes the data platform, for Dubai construction, environment, energy, innovation and investment sector.

Each construction project and building type/usage could benefit from the extensive range of solutions, systems and smart applications according to stakeholders' requirements, Stakeholders were involved, in view of their experience, objectives, actions and requirements.

4.3. Interview Results Analysis

Two interviews were conducted:

- one with Honeywell Consultant company, meeting with Dr. Sebastian
- one with ABB Manufacturer company, and a site visit for one of the ABB project / Medan Project (luxury villa with complete smart buildings systems)

4.3.1. Honeywell Rating System

Honeywell is the leading Consultant and Manufacturing Company for smart building products in cooperation with EY in the Middle East and North Africa (MENA) region.

Honeywell conducted a study through the MENA region using the Honeywell Smart Building score on 600 buildings across 7 cities, in 4 countries. The main score elements is (Green, Safe and productivity), as noted the green building specification was used as a main score element through the study.

The Honeywell framework is shown, in below, figure 4.26, noted there is 15 Assets that was divided into three categories (Green, Safe and Productive) and three components (if the system was applied or not, the system coverage and the system uptime) as shown in figure 4.39.

Figure 4.39 Honeywell Score Framework, (Honeywell, 2016)

The building category and age was also taken in consideration through the score process and having the green building certificate gives a 50% higher score. In the analysis stage of the results, most building managers regarded safety as the most important category mainly in residential buildings and airports. Following by the productivity, and last the green aspects.

4.3.2. ABB System

ABB is another worldwide leader manufacturer and provider of smart home, smart building solutions with social and environmental sustainability.

A visit for the Manufacturer and the supplier of the smart system, in an interview with ABB representative, engineer, Mohammed Jabir, specialist sales engineer for smart building system in the ABB Company. The Smart building definition as per the specialist point of view was a "smart building is to be connected and automated, where the building takes decision by itself, to increase comfort, safety and efficiency",

Their smart building systems are based on KNX open protocol, ABB categorization strategy dividing buildings in two main categories:

- Living Space Solutions

Includes all buildings with residential usage:

- Single family homes
- Apartment buildings
- High rise buildings
- Hotels and hospitality

To give the apartment or villa owner full control on each detail indoor and outdoor, as shown in below figure including (temperature, safety, lighting, network, energy metering, etc.). All features could be controlled by voice, phone or tablet, focusing on the following factors: **Comfort** takes the higher weight, **safety** and finally **energy control**.

Figure 4.40 ABB smart living space solutions,

(ABB, http://new.abb.com/buildings, 2016)

- Building Space Solutions:

Includes 8 building types as follows (any public buildings, leisure, health, shopping and educational usages.):

- Commercial buildings
- Industrial buildings
- Stadium and recreation buildings
- Education buildings
- Hotels and hospitality
- Health care
- Transport
- Office buildings

Providing many features as shown in figure 2.4, such as (shading, electrical distribution and protection, energy management and etc.), focusing on the following factors: **Comfort** takes the higher weight, **safety** and finally **lower utility bills and flexibility.**

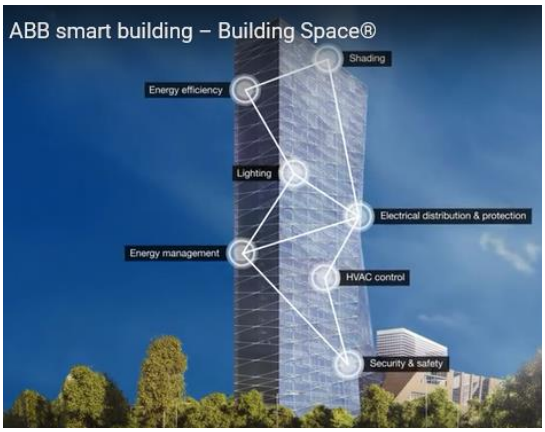


Figure 4.41 ABB smart building space solutions, (ABB, 2016) available at:

(http://new.abb.com/buildings)

ABB Focusing on achieving six main cores in smart buildings:

- Economic efficiency (saving in utility bills and running cost)
- Design (comfort in all details)
- Safety (To function automatically and securely)
- Durability (Flexibility to new updates and upgrades)
- Energy efficiency (Max. Energy Management)
- Sustainability (Energy savings)

Furthermore, a site visit was conducted to Medan Project (District one) which was a villas compound project in Mohammed Bin Rashid Al Maktoum City is located in Nad Al Sheba, a future residential revolution with 1,600 luxury villas, which are fully equipped with the most developed smart systems from ABB, the villa area is between (20,000 – 25,000) foot squared, the cost for smart building systems reached less than 5% of the total Building cost approximately.

Figure 4.42 District One project, Dubai, Available at: (http://meydansobha.com)

Figure 4.43 The Villa Entrance and Control Panel in the entrance loopy

Figure 4.44 Spot light (Smart Touch) switches, the Master Bedroom switches, the living area and the kitchen

As shown in above figures all villa switches are smart with touch interface option for (music and sound system control, light, AC and spot lights), the villa is provided with a main control panel in the entrance loopy as in figure 4.30.

Figure 4.45 Cinema Room control Touch screen

Also home cinema hall is provided by another control panel, where villa residents could control and set cinema room temperature, AC and the lighting theme plus the cinema scene.

Figure 4.46 Servers' room and Servers control touch screen

The villa has small server room (2.5 m * 2.5 m) in the basement floor also provided with separate control panel (figure 4.33), to view data and energy consumption, and work as data dashboard.

In general, the villas' owners feedback indicated that they were satisfied, happy and feeling safe, due to the smart systems provided in the villa, which was friendly and easy to use and handle.

4.3.3. Section Conclusion

The interview with the different market vendors showed a summary for the challenges that phases implementing smart building in Dubai, as per Honeywell; safety is a main goal in most of the existing buildings, where building integration was only in 57% of the six hundred buildings surveyed, also one of the most important enablers for the implementation is the policies, governmental support and city regulations.

ABB uses different categorization for the building compared with Honeywell based on living and building spaces.

The smart system should have the ability to be multi-function that could be controlled through one button and multi devices such as (mobile, Tablet, laptop and PC).

Regarding the lighting system in hotels, it is focusing on the dimming, where in public buildings for instance, it is focusing on timing. System customization and data export is another component of preferred feature.

From some specialist point of view, the ability of connecting any system on the BMS was a very major factor for integration implementation which could be obtained through using open protocols such as BacNet and KNX, and the building system ability to connect to the Wi-Fi and internet, the same results in the survey responses with a high selection percentage for providing Wi-Fi.

4.4. Chapter Conclusion

The survey and the interview results in regard to exploring the readiness of stakeholder's in Dubai for the implementation of SB and the smart building score used, delivered a clear vision towards the aim of the survey. A broad evaluation of construction sector opinion in the implementing process and the expected impacts, which provided direction toward developing the implementation strategy, was provided. Results and its effects on the development of the frame work plan will be discussed in the next chapter.

Chapter Five

Research Results Discussion

5.1. Chapter Introduction

This chapter includes analysis for the survey results with relation to the literature review and the interview results, to develop implementation framework plan.

It includes discussion of the research aim and objectives, the end result of this section will be the proposed framework plan. A detailed comparison between different cores used to evaluate SB, the needed component for each system were also presented in this section.

5.2. Smart Buildings Implementation Requirements

This research presented best practices of several stakeholders and leading cities in the implementation of smart buildings, in order to collect their experience for developing the implementation framework, strategy and rank criteria, through combining the advantages that suits Dubai buildings.

Buildings and Facilities are the conducting environment for all activities and services in the city, where humans spend most of the time, the buildings is the geographical place for each individual; buildings are the most important element for human comfort for their different activities. In order for buildings to be ready for the future requirement, full infrastructure from (electric, electronic, data, wire an wireless) networks, and sensors and automated software's with a degree that satisfies the upcoming future are required.

Next phase collect all human development in the different aspects of life, and it is a must to integrate between all these aspects , as the development is related to the integration of them, where the human behaviour tends toward comfort ,less effort and time, the industry tends towards automation and programmed control. The reduce reliance on human effort providing services and products which meets all humans requirements to provide simplicity and comfort for humans is important.

Nowadays, the sciences of programming and new technologies are developing very fast, in order to comply with the continuous life requirements, which open new visions to the future and the industrial transfer, to fulfil the new control, communications and connections demands for all aspects of human being life form the (learning , transport, accommodation, health ,, etc.). A new life generation is starting using innovation and

smart technologies to provide new means, which all can be displayed by below smart life diagram below, reveals the main elements for building the future:

- Industry
- Information Technologies
- Communication Technologies
- Control Techniques

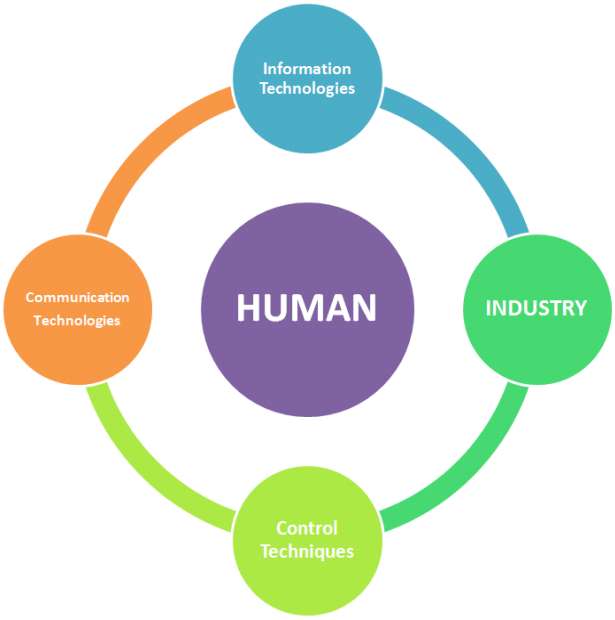


Figure 5.1 Future Building Main Elements Diagrams'

All these elements are connected; success cannot be achieved unless all elements are completely integrated and related to all new human requirements, as each element represent a source for ideas and innovations. With the developing communication and control technologies, there is no limits for the smart use of data and information, where data and information the vital element of the diagram.

5.3. Dubai Stakeholders' Readiness

Responsibility towards the next stage as speed of upcoming developments are clearly noticed in industry and economy and all other life aspects (governmental and private services, education, health) which is being translated in the strategic plans for the United Arab of Emirates and the Emirates of Dubai. Networking and data base and data control is a main requirement to obtain the goals and targets, these strategic plans should cover (UAE vision2021, 2016):

- Vision and mission
- Resources and enablers
- Innovation and copy rights
- Regulations and Systems
- Standards and Guidelines
- Data and information

All points above are supported by UAE government as a base for all governmental entities in Dubai through the new sample for Governmental excellence, this vision is shaped a difference and a motivation for hard work building the foundation of the future environment.

From that point, the related aspect is preparing a building environment which will enable the above governmental and future requirements for the next phase.

Because smart services and smart programmes are a main vision for the next phase, then it is needed to provide a complete framework for the implementation and guidelines which satisfies the required smart services inside buildings. That is the core of this research.

5.4. Implementation Framework Plan

Through studying all smartness keys and tools and selecting the suitable for Dubai Buildings depends on the building type and usage, based on best practices, and the conducted survey and interviews.

Building shapes a major sector of Dubai's future and vision to be smart, happy and sustainable city; therefore there should be minimum requirement in order to consider building smart. To implement Smart Building in a City there should be a clear strategy that includes following phases:

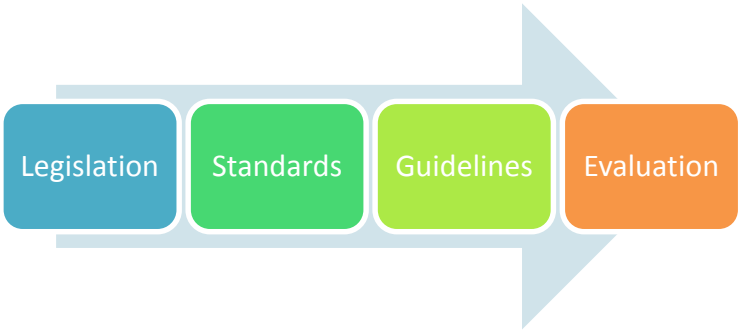


Figure 5.2 Smart Building Implementation Strategy Phases

Smart Building Implementation Strategy includes specifying governmental implementation requirements through setting out legislation and standards, in addition to guidelines on how this is to be implemented. An assessment or checklists that measures and evaluates the intelligence degree of the building in order to issue a smart building certificate, and building type to be mandatory smart, which should be left optional. (Refer to Table 5.1, 5.2, 5.3).

Referring to the interview with HoneyWell and the literature review in section 2.3, and the survey results, comparing the requirements for smart building in Dubai, because of the high percentage of high rise buildings BMS was considered as major system in the most important building types, for the safety focusing on the firefighting systems was a

major concern in Dubai because of the high temperature climate, in Taiwan the focus was on the disaster consideration relating to the city nature, in Taiwan, the accreditation process was divided in two main principles (infrastructure/functional), focusing on integration of systems and safety factor from disasters. A comparison was derived to achieve the main cores of smart buildings in this research, as shown in Table 5.1:

<table>
<tr><th>Smart Building in</th><th colspan="4">Main Cores/ Categories</th></tr>
<tr><td rowspan="2">Honey Well</td><td>Green</td><td colspan="2">Safe</td><td>Productive</td></tr>
<tr><td>(HVAC/ (power control/ energy efficiency/ use of natural resources)</td><td colspan="2">(surveillance/ fire detection/ access control/ disaster response/ leakage detection/ worker safety)</td><td>(Wired /Wi-Fi / indoor quality control)</td></tr>
<tr><td rowspan="2">Taiwan</td><td colspan="2">Infrastructure</td><td colspan="2">Functions</td></tr>
<tr><td>(wiring & cabling, Data & communication)</td><td>(integration of systems, facility management)</td><td>(safety, health & comfort, convenience)</td><td>(energy efficiency & management)</td></tr>
<tr><td rowspan="2">Dubai (Research Case)</td><td>Smart Infrastructure</td><td>Smart Energy</td><td>Safety & Security</td><td>Comfort, Health & Happiness</td></tr>
<tr><td>ICT networks, Wi- Fi</td><td>Smart BMS , Smart energy control (lighting and HVAC)</td><td>(Smart security systems and smart fire fighting systems)</td><td>(Air quality control, smart water control, other smart systems and Smart Device Control)</td></tr>
</table>

Table 5.1 Smart Building Core Comparison

Dubai Smart Building Index: No of smart building systems provided in the building (From 0: Not Smart Building to 100: Very Smart Building)

Analysis Base for new permitted buildings:

- Building Type /Usage
- Smart Building System Provided
- Smart Building Systems Requirements
- Smart Building Index

Smart Building Certificate: Each smart system was given a grade depending on the building type and priority mapping shown in Table 5.2. The analysis of the Smart Systems Priority Mapping by Building Type was achieved from the results to question no.15 in addition to some factors related to owner type (government or private sector), where the implementation should begin from the regulator side, for public and governmental buildings to be a row model for the private sector.

As noted in the table below, the highest priority were for hotels, hospitals, governmental and public buildings, contrasting this villas and industrial building were the least priority for implementation. The smart systems were categorised by priority into: High priority: infrastructure is the basic; the integration is the most important element in smart building, and security/ Medium Priory: water control and other smart systems such as parking and elevators control/ Low priority: smart devices such as fridges and printers.

Smart System was graded by multiples of (5), dividing the total grade 100 into the (9) main smart systems, system with the highest priority and basic requirements were given grade (15), also major higher priority systems was given grade (10), and lower system priority was given grade (5), as follows (for system briefs refer to section 2.2.3 Smart Building Systems):

- Data Communication Infrastructure, Networks: (15)
- Smart BMS & Zones Control: (15)
- Smart Energy Control **(Lighting and HVAC)**: each system (10) with total of (20)
- Smart Fire Fighting and safety Sys.: (10)
- Smart Security Sys.: (10)
- Health and Environment Control Sys. (Air Quality) : (10)
- Smart Water Control Sys. : (10)
- Other Smart Sys. (Elevators, Central Gas, Parking, etc.): (5)
- Smart Device Control (printer, screens, TV, etc.): (5)

From table 5.3 Dubai Smart Building Systems could be categorized to 4 main cores:

- **Smart infrastructure (15% total)**: ICT networks (10%), Wi Fi (5%)
- **Smart Energy (Efficiency, Effectiveness, and Integration) (35% total)**: Smart BMS (15%), Smart energy control [lighting (10%) and HVAC (10%)].
- **Safety & Security (20% total)**: Smart security systems (10%) and smart fire fighting systems (10%)

- **Comfort, Health & Happiness (30% total)**: Air quality control (10), smart water control (10%), other smart systems (elevators, parking, etc.) (5%) and Smart Device Control (5%)

The implementation plan/year in Table 5.4 was indicated depending on the mentioned priories explained previously for the building types and the systems importance. Table 5.5 shows the basic components/ requirements of each smart building system which are considered as mandatory and the fundamental requirements which are considered as optional. (for system briefs refer to section 2.2.3).

The highest grades were given to Hotels, Governmental and Public building to be the first to implement the smart systems in its project, these building types are related to the most important sectors in the city the governmental sector, and hotels shapes the largest category in investment sector in Dubai. That is why the implementation plan launching starts with these building types regarding the timeframe plan, indicated in Table 5.4.

Industrial Building, Private and Investment Villas were left to be implemented after one year of implanting for hotels, governmental and public buildings, as strategy to encourage private owners to implement in their own villas, with industrial building taking lower priority, as noted in the survey results of Figure 4.19, compared to other building types, due to the nature of usage.

Table 5.2 Smart Systems Priority Mapping by Building Type

Smart Systems Priority Mapping by Building Type	Private Villas	Investment Villas	Residential Buildings	Offices Buildings	Commercial Buildings	Industrial Buildings	Governmental Buildings	Public Buildings	Educational Buildings	Hospitals and Medical Centres'	Hotels and Hotel Apartments	Airports
Smart Energy Control Sys. (lighting, HVAC, ..etc.)	77.14%	76.19%	85.71%	89.52%	84.76%	67.62%	93.33%	89.52%	87.62%	91.43%	90.48%	85.71%
Smart Security Sys.	50.48%	52.38%	84.76%	83.81%	83.81%	68.57%	89.52%	89.52%	88.57%	91.43%	86.67%	88.57%
Data Communication Infrastructure, Networks	48.57%	51.43%	73.33%	87.62%	81.90%	59.05%	89.52%	87.62%	85.71%	90.48%	86.67%	89.52%
Smart Fire Fighting and safety Sys.	54.29%	56.19%	87.62%	80.95%	83.81%	76.19%	85.71%	83.81%	89.52%	91.43%	90.48%	88.57%
Health and Environment Control Sys. (Air Quality)	54.29%	58.10%	79.05%	80.95%	80.00%	72.38%	83.81%	85.71%	89.52%	94.29%	91.43%	90.48%
Smart Water Control Sys.	60.95%	62.86%	77.14%	71.43%	67.62%	58.10%	80.00%	80.00%	76.19%	88.57%	87.62%	86.67%
other Smart sys(Elevators, Central Gas, parking...etc...)	26.67%	28.57%	72.38%	73.33%	74.29%	44.76%	80.00%	78.10%	70.48%	81.90%	84.76%	82.86%
Smart BMS & Zones Control	18.10%	20.95%	60.95%	69.52%	65.71%	41.90%	78.10%	71.43%	68.57%	85.71%	86.67%	78.10%
Smart Device Control (printer, screens, TV, ..etc.)	38.10%	37.14%	43.81%	63.81%	46.67%	35.24%	64.76%	55.24%	58.10%	69.52%	74.29%	67.62%

80% - 100%	High Priority
60% - 79%	Medium Priority
0% - 59%	Low Priority

Table 5.3 Final Smart Building Implementation Formwork and Assessment

Smart Building Implementation Formwork and Assessment																				
Systems Category			Smart Building Infrastructure		Smart Energy System								Smart Building Management System	Safety and Security Systems						
#	Building Type/Usage	Final Degree for each Building	Wi Fi Network	Data Communication Infrastructure, ICT Networks	smart energy control (lighting)	smart energy control (HVAC)	Health and Environment Control Sys. (Air Quality)	Smart Water Control Sys.	Smart Sys. (Elevators, Central Gas, Parking, etc.)	Smart Device Control			Smart BMS & Zones Control	Smart Security Sys.	Smart Fire Fighting and safety Sys.					
	Rating degree for providing each smart system	100%	5%	10%	10%	10%	10%	10%	5%	5%			15%	10%	10%					
1	Governmental Buildings	95%	☒	☒	☒	☒	☒	☒	☒	□			☒	☒	☒					
2	Public Buildings *	95%	☒	☒	☒	☒	☒	☒	☒	□			☒	☒	☒					
3	Hotels and Hotel Apartments	100%	☒	☒	☒	☒	☒	☒	☒	☒			☒	☒	☒					
4	Multi Storey Buildings (Commercial, Residential, Offices)	80%	☒	☒	☒	☒	☒	☒	☒	□			□	☒	☒					
5	Investment Villa	65%	☒	☒	☒	☒	☒	☒	□	□			□	□	□					
6	Private Villas	65%	☒	☒	☒	☒	☒	☒	□	□			□	□	□					
7	Industrial Buildings	30%	□	□	☒	☒	□	□	□	□			□	□	□					

☒ : Mandatory Implementation □ : Optional Implementation

Public Buildings * : includes (Airports, Shopping Centres', Mosques, Theatres, Sport Clubs, Metro Stations and Parks, etc.).

Table 5.4 Final Smart Building Implementation Plan /Year

<table>
<tr><th colspan="13">Smart Building Implementation Plan by Year</th></tr>
<tr><th colspan="2">Systems Category</th><th colspan="2">Smart Building Infrastructure</th><th colspan="6">Smart Energy System</th><th>Smart Building Management System</th><th colspan="2">Safety and Security Systems</th></tr>
<tr><th colspan="2">Building Type/Usage</th><th>Wi Fi Network</th><th>Data Communication Infrastructure, ICT Networks</th><th>smart energy control (lighting)</th><th>smart energy control (HVAC)</th><th>Health and Environment Control Sys. (Air Quality)</th><th>Smart Water Control Sys.</th><th>Smart Sys. (Elevators, Central Gas, Parking, etc.)</th><th>Smart Device Control</th><th>Smart BMS & Zones Control</th><th>Smart Security Sys.</th><th>Smart Fire Fighting and safety Sys.</th></tr>
<tr><td>1</td><td>Governmental Buildings</td><td colspan="2" rowspan="6">Q1/ 2018</td><td rowspan="3">Q1/ 2018</td><td rowspan="3">Q1/ 2018</td><td rowspan="3">Q1/ 2018</td><td rowspan="3">Q1/ 2018</td><td>Q1/2019</td><td>-</td><td rowspan="3">Q1/ 2018</td><td rowspan="3">Q1/ 2018</td><td rowspan="4">Q1/ 2018</td></tr>
<tr><td>2</td><td>Public Buildings *</td><td>Q1/2019</td><td>-</td></tr>
<tr><td>3</td><td>Hotels and Hotel Apartments</td><td>Q2/2018</td><td>Q4/ 2019</td></tr>
<tr><td>4</td><td>Multi Storey Buildings (Commercial, Residential, Offices)</td><td rowspan="4">Q2/ 2019</td><td rowspan="4">Q2/ 2019</td><td rowspan="3">Q2/ 2019</td><td rowspan="3">Q2/ 2019</td><td>Q4/2019</td><td>-</td><td>-</td><td>Q1/2019</td></tr>
<tr><td>5</td><td>Investment Villa</td><td>-</td><td>-</td><td>-</td><td>-</td><td>Q4/2019</td></tr>
<tr><td>6</td><td>Private Villas</td><td>-</td><td>-</td><td>-</td><td>-</td><td>Q4/2019</td></tr>
<tr><td>7</td><td>Industrial Buildings</td><td colspan="2">-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>Q1/2019</td></tr>
</table>

Table 5.5 Final Smart Systems Requirements

*(For systems brief, refer to section 2.2.3)

Smart Systems Requirements									
#	Smart Building Systems	Smart Systems Basic Components							
1	Data Communication Infrastructure, Networks	Wire Data Network M		WI FI network M		Sound sys. Network O		TV network O	
2	smart energy control (lighting and HVAC)	Smart HVAC M		Smart Lighting M		Smart Shading O		Smart curtains O	
3	Health and Environment Control Sys. (Air Quality)	Air quality M		Water Quality O					
4	Smart Water Control Sys.	Smart Water Control M		Smart irrigation sys. O		Smart water recycling sys. O			
5	Smart Sys. (Elevators, Central Gas, Parking, etc.)	Smart Parking sys. M		Smart Elevator sys. M		Smart Central Gas sys. M		Occupation sys. O	
6	Smart Device Control	Smart Printers O		Smart Fridges O		Smart Oven O		Smart dishwashers O	
7	Smart BMS & Zones Control	Integrated Smart Building Management System M				Servers Network M			
8	Smart Security Sys.	Access Control Systems (Doors/ gates /entrances) M		External Monitoring Sys. M		Internal Monitoring sys. O		Swimming pools safety sys. M	
9	Smart Fire Fighting and safety Sys.	Smart Sensors M		Smart sprinklers control O		Smart Smoke Detectors O			
		M: mandatory		O: optional					

5.5. Impacts, Benefits, Limitations and Challenges

5.5.1. Impacts and Benefits of Smart Buildings:

- Standardized building systems enable simple upgrade modifications of control systems, to meet facility needs.
- Higher building value and higher leasing rates and incomes can be reached.
- Cost of energy consumption are managed and minimized through zone control on a time of day schedule; reducing running cost.
- Increasing building operating efficiency and building systems effectiveness.
- Adopting future engineering development and new technologies
- Positive Impacts on happiness, comfort and health of occupants
- Increasing Satisfaction degree for occupants and residents
- Provide data statics, detailed building data and consumption reports in addition to key performance indicators KPI's through dashboards.

5.5.2. Limitations and Challenges:

Smart buildings are the buildings of the future. However, the limitation of them cannot be anticipated. From a simple view:

- Privacy of Building Occupants' and Data Security: IoT internet of things increases the anxiety about privacy and ensuring data security due to the constant increase of hacking, cyber threats percentage, this is over the responsibility of the IT administrators', IT developers, develop highly protected software's and BMS, requires government to take legal actions and set regulation policies.
- Cost of Smart Building Systems: A major barrier to the introduction of technology, as there the upfront cost but in the same time there is a continuous saving during the

life time cycle of the building. Overcoming this can be through providing awareness about the actual initial cost of smart building implementation; which will not exceed 10% of the total building cost, and increase the building owners' awareness regarding the resulting benefits of applying the smart systems. Economics increasingly motivate

- IT administrators' usually hesitate to allow operating of BA building automation through the corporate IT network, this could be overcome through the early coordination between SBSs vendors and IT administrators' to answer concerns and inquiries about servers, networks and cloud privileges'.
- Maintenance of smart systems: BMS and all system maintenance in a regular base are very important to prevent and minimize failures.
- Assuring that smart building potentials (the used technologies) meet the needs of the occupants and the building requirements need to be operated.
- The capabilities of the building operators and their experience, another important barrier which could be overcome through proper training on BAS, BMS, and all smart building systems features'.
- Before the standards and protocols was considered as challenging but nowadays many open protocols have been developed such as (KNX, BACnet), to overcome this issue, integrate and connect different systems from different vendors through unified management systems.

5.6. Chapter Conclusion

This Chapter summaries the findings, the results of the survey and the interviews.

A detailed discussion was also addressed, in addition to combined discussion for the results' analysis of survey and interviews.

There should general awareness programmers and seminars to all stakeholders about the implementation strategy, framework, benefits and policies. Advanced and technical programs should also be conducted to the designer and contractor who are executing the buildings projects.

Interviews indicated that living space smart components should be left optional; especially villas, as also the survey results was matching the interview results, where providing smart systems in villas have taken the lowest percentage of responses.

The specialist focused on providing smart systems mandatory in Governmental buildings, public buildings, hotels, high-rise buildings and airports, where in question 15 in the survey, it was noticed that these types have taken the highest percentage to be provided with smart systems.

Regarding the lighting system in hotels, it is focusing on the dimming, where in public buildings for instance, it is focusing on timing. System customization and data export are additional preferred features.

Chapter Six

Conclusions and Recommendations

6.1. Chapter Introduction

This chapter presents the summary of the results and the detailed analysis of the findings as per all chapters previously, linking the findings to the aims and main objectives of this research, containing the advised recommendations.

6.2. Conclusions

Based on the literature review, the survey and interviews results and analysis, towards the aim of this research to develop clear index framework for Dubai Smart Building implementation and rank criteria during the permitting process of the building, **Dubai Smart Building Systems** could be categorized into:

- **Smart infrastructure (15%)**
- **Smart Energy (Efficiency, Effectiveness, and Integration) (35%)**
- **Safety & Security (20%)**
- **Comfort, Health & Happiness (30%)**

With total grade of 100%.

6.3 Recommendations

Based on the conclusion and results analysis in this research, the following are the recommendations for future Buildings Smartness Framework, as that represent very crucial phase in developing the building construction sector:

- Coordination between all parties of stakeholders, beginning with the governmental sector reaching the buildings' owners, to raise the awareness and knowledge of each party.
- Coordination between governmental sector and vendors (manufacturers and suppliers of SBSs) for advanced training courses, addressed to building permit engineers and specialists from consultant and contractors companies.
- Starting the first phase of mandatory implementation on governmental building and public building to be a row model for all buildings.
- Set extra effort to develop the details for the framework and action plan.
- To provide guidelines and set clear standards by the governmental authorities.
- Coordination between different governmental authorities (Dubai Municipality, DEWA Dubai Electricity and Water Authority, DCD Dubai Civil Defence and Dubai Police) is highly required to achieve full integrated management for the implementation plan.
- Initiating a strategy for the next phase towards the buildings of future for supervision process, systems accreditation through developing Smart Buildings Evaluation Association in the emirates of Dubai.

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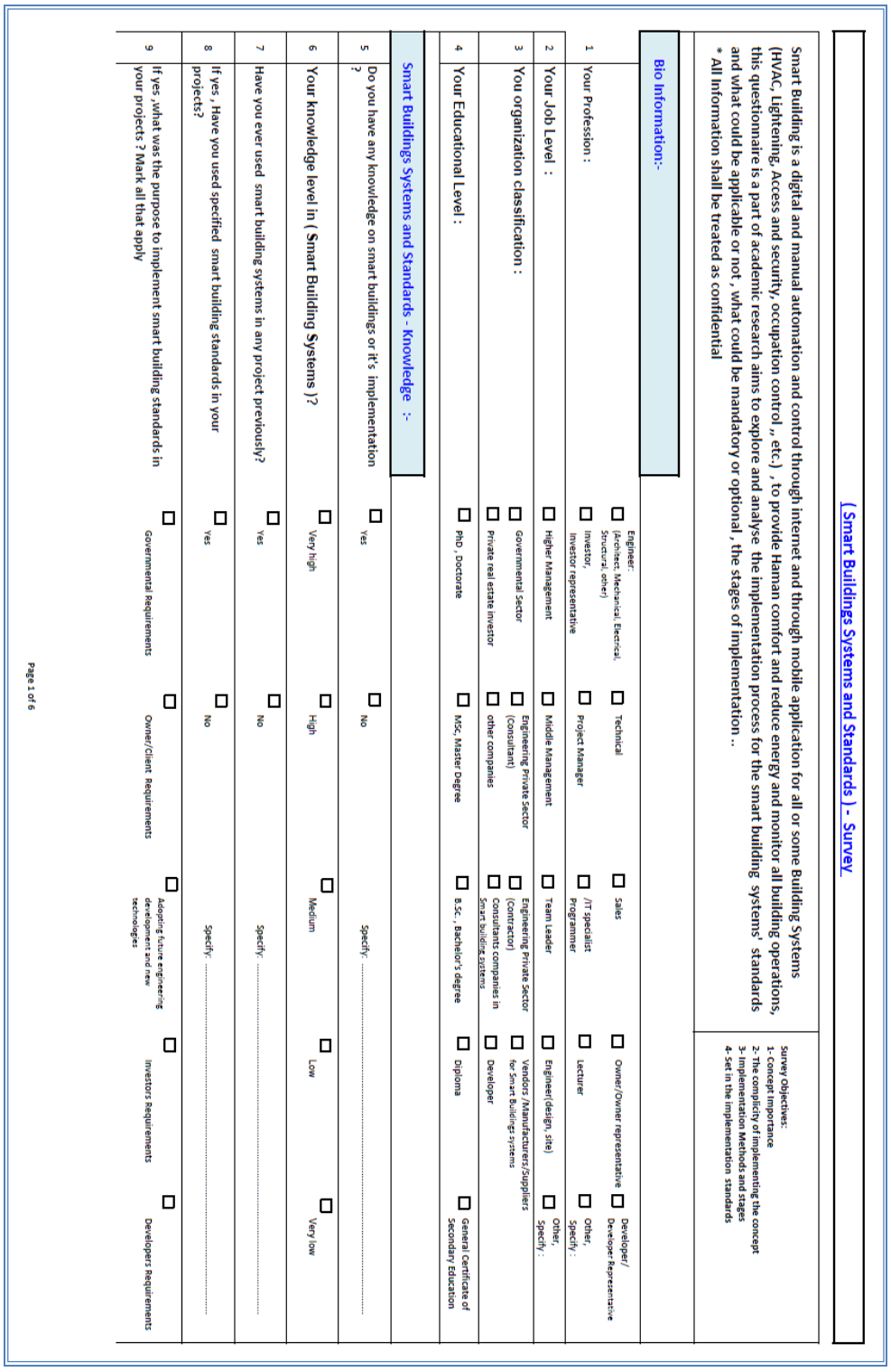
Appendix (A)

Appendix A-1 Draft Survey



(Smart Buildings Systems and Standards) - Survey

Smart Building is a digital and manual automation and control through internet and through mobile application for all or some Building Systems (HVAC, Lightening, Access and security, occupation control ,, etc.) , to provide Haman comfort and reduce energy and monitor all building operations, this questionnaire is a part of academic research aims to explore and analyse the implementation process for the smart building systems' standards and what could be applicable or not , what could be mandatory or optional , the stages of implementation ..

* All information shall be treated as confidential

Survey Objectives:
1- Concept importance
2- The complicity of implementing the concept
3- Implementation Methods and stages
4- Set in the implementation standards

Bio Information:-

1 Your Profession : ☐ Engineer: (Architect, Mechanical, Electrical, Structural, other) ☐ Technical ☐ Sales ☐ Owner/Owner representative ☐ Developer/ Developer Representative ☐ Investor, investor representative ☐ Project Manager ☐ /IT specialist Programmer ☐ Lecturer ☐ Other, Specify :

2 Your Job Level : ☐ Higher Management ☐ Middle Management ☐ Team Leader ☐ Engineer(design, site) ☐ Other, Specify :

3 You organization classification : ☐ Governmental Sector ☐ Engineering Private Sector (Consultant) ☐ Engineering Private Sector (contractor) ☐ Vendors /Manufacturers/Suppliers for Smart Buildings systems ☐ Private real estate investor ☐ other companies ☐ Consultants companies in Smart building systems ☐ Developer

4 Your Educational Level : ☐ PhD , Doctorate ☐ MSc, Master Degree ☐ B.Sc. , Bachelor's degree ☐ Diploma ☐ General Certificate of Secondary Education

Smart Buildings Systems and Standards - Knowledge :-

5 Do you have any knowledge on smart buildings or it's implementation ? ☐ Yes ☐ No Specify; .....

6 Your knowledge level in (Smart Building Systems)? ☐ Very high ☐ High ☐ Medium ☐ Low ☐ Very low

7 Have you ever used smart building systems in any project previously? ☐ Yes ☐ No Specify; .....

8 If yes , Have you used specified smart building standards in your projects? ☐ Yes ☐ No Specify; .....

9 If yes ,what was the purpose to implement smart building standards in your projects ? Mark all that apply ☐ Governmental Requirements ☐ Owner/Client Requirements ☐ Adopting future engineering development and new technologies ☐ Investors Requirements ☐ Developers Requirements

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Appendix (A)

	☐ Reducing Building operation cost	☐ Energy Savings	☐ Increasing efficiency and effectiveness of building systems	☐ Achieving human Comfort	
10	Your experience in Smart Building :	☐ Very high	☐ High	☐ Medium	☐ Low	☐ Very low
11	Your Staff experience in Smart Building Systems :	☐ Very high	☐ High	☐ Medium	☐ Low	☐ Very low
	Smart Building Systems and Standards - Importance : -					
12	Importance of providing buildings with Smart systems :	☐ Very important	☐ Important	☐ neutral	☐ Not important	☐ Not important at all
13	Implementing Smart building systems is important because this achieves:	☐ Governmental Requirements	☐ Owners, Investors and Developers Requirements	☐ Tenants Requirements	☐ Saving in energy consumption	☐ Human Comfort
14	The most important Smart Building systems is : kindly arrange from 1 to 10 , where (1: is the most important , 10 : is the least important)	☐ Data and communication infrastructure and Networks	☐ Energy Control Systems (Smart HVAC and Lighting)	☐ Security system CCTV	☐ Health and Environment control system (AIR quality)	☐ Water Control Systems
		☐ Smart Devices control (printers, TV, Screens , fridge, washing Machine)	☐ Smart Fire fighting and Public Safety (Civil defence systems)	☐ Smart Building Management System (BMS and zones control	☐ Smart Parking and occupation systems	☐ Other Smart system (elevators ...)
15	From your point of view : There should be detailed standards for each system of the smart building systems , or manufacturers standards' is enough ?	☐ Yes	☐ No	☐ Other, specify :		
16	From your point of view : Issuing Smart Building Standards is the responsibility of:	☐ Dubai Municipality	☐ Smart Buildings systems - Vendors/ Manufacturer/Suppliers	☐ Consultants	☐ Contractors	☐ other, Specify :
17	Do you think that implementing detailed standards for the smart building systems will improve (the efficiency and effectiveness of the smart systems) in the buildings ?	☐ Yes	☐ No			
18	The Importance degree for implementing detailed standards for smart building systems in buildings :	☐ Very important	☐ Important	☐ neutral	☐ Not important	☐ Not important at all

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Smart Buildings' Systems and Standards - Implementation Fields and Limits

19	From your point of view : the cost of installing smart building systems in buildings is the responsibility of:	☐ Buildings Owners	☐ Tenants	☐ Both					
20	From your point of view : the responsibility of owners is limited to provide the following for the residential unit : (select where applicable-multiple choice)	☐ Wi-Fi (internet Network)	☐ Smart Networks and it's requirements	☐ Infrastructure and cables	☐ Smart Sensors	☐ Smart Switches			
21	The implementation of smart building systems and standards will be in the interest of : (select where applicable-multiple choice)	☐ Owners/ Developers/Investors	☐ Tenants	☐ Buildings Operators	☐ Vendors and manufacturers	☐ consultants			
		☐ Contractors	☐ Dubai Municipality	☐ DEWA -Water	☐ DEWA-Electricity	☐ Civil Defence			
22	Which of these smart building systems should be implemented in (residential Villas) , in order for the villa to get Smart Building Certificate ? (select where applicable-multiple choice)	☐ Data and communication infrastructure and Networks	☐ Energy Control Systems (Smart HVAC and Lighting)	☐ Security system CCTV	☐ Health and Environment control system (AIR quality)	☐ Water Control Systems			
		☐ Smart Devices control (printers, TV, Screens , fridge, washing Machine)	☐ Smart Fire fighting and Public Safety (Civil defence systems)	☐ Smart Building Management System IBMS and zones control	☐ Smart Parking and occupation systems	☐ Other Smart system (elevators ...)			
23	Which of these smart building systems should be implemented in buildings with residential apartment usage , in order for the building to get Smart Building Certificate ? (select where applicable-multiple choice)	☐ Data and communication infrastructure and Networks	☐ Energy Control Systems (Smart HVAC and Lighting)	☐ Security system CCTV	☐ Health and Environment control system (AIR quality)	☐ Water Control Systems			
		☐ Smart Devices control (printers, TV, Screens , fridge, washing Machine)	☐ Smart Fire fighting and Public Safety (Civil defence systems)	☐ Smart Building Management System IBMS and zones control	☐ Smart Parking and occupation systems	☐ Other Smart system (elevators ...)			
24	Which of these smart building systems should be implemented in buildings with offices usage , in order for the building to get Smart Building Certificate ? (select where applicable-multiple choice)	☐ Data and communication infrastructure and Networks	☐ Energy Control Systems (Smart HVAC and Lighting)	☐ Security system CCTV	☐ Health and Environment control system (AIR quality)	☐ Water Control Systems			
		☐ Smart Devices control (printers, TV, Screens , fridge, washing Machine)	☐ Smart Fire fighting and Public Safety (Civil defence systems)	☐ Smart Building Management System IBMS and zones control	☐ Smart Parking and occupation systems	☐ Other Smart system (elevators ...)			
25	Which of these smart building systems should be implemented in buildings with commercial usage , in order for the building to get Smart Building Certificate ? (select where applicable-multiple choice)	☐ Data and communication infrastructure and Networks	☐ Energy Control Systems (Smart HVAC and Lighting)	☐ Security system CCTV	☐ Health and Environment control system (AIR quality)	☐ Water Control Systems			
		☐ Smart Devices control (printers, TV, Screens , fridge, washing Machine)	☐ Smart Fire fighting and Public Safety (Civil defence systems)	☐ Smart Building Management System IBMS and zones control	☐ Smart Parking and occupation systems	☐ Other Smart system (elevators ...)			

Appendix (A)

26	Which of these smart building systems should be implemented in buildings with Governmental usage , in order for the building to get Smart Building Certificate ? (select where applicable-multiple choice)	☐ Data and communication infrastructure and Networks	☐ Energy Control Systems (Smart HVAC and Lighting)	☐ Security system CCTV	☐ Health and Environment control system (AIR quality)	☐ Water Control Systems	☐ Smart Devices control (printers, TV, Screens , fridge, washing Machine)	☐ Smart Fire fighting and Public Safety (Civil defence systems)	☐ Smart Building Management System IBMS and zones control	☐ Smart Parking and occupation systems	☐ Other Smart system (elevators ...)
27	Which of these smart building systems should be implemented in buildings with Hotels usage , in order for the building to get Smart Building Certificate ? (select where applicable-multiple choice)	☐ Data and communication infrastructure and Networks	☐ Energy Control Systems (Smart HVAC and Lighting)	☐ Security system CCTV	☐ Health and Environment control system (AIR quality)	☐ Water Control Systems	☐ Smart Devices control (printers, TV, Screens , fridge, washing Machine)	☐ Smart Fire fighting and Public Safety (Civil defence systems)	☐ Smart Building Management System IBMS and zones control	☐ Smart Parking and occupation systems	☐ Other Smart system (elevators ...)
28	Which of these smart building systems should be implemented in buildings with Health usage (hospitals) , in order for the building to get Smart Building Certificate ? (select where applicable-multiple choice)	☐ Data and communication infrastructure and Networks	☐ Energy Control Systems (Smart HVAC and Lighting)	☐ Security system CCTV	☐ Health and Environment control system (AIR quality)	☐ Water Control Systems	☐ Smart Devices control (printers, TV, Screens , fridge, washing Machine)	☐ Smart Fire fighting and Public Safety (Civil defence systems)	☐ Smart Building Management System IBMS and zones control	☐ Smart Parking and occupation systems	☐ Other Smart system (elevators ...)
29	Your support level for implementing Smart Building standards :	☐ Very high	☐ High	☐ Medium	☐ Low	☐ Very low					
30	From your point of view : (Owners, Investors and Developers) Readiness and Support degree of to provide smart building systems and apply the standards in their projects?	☐ Very high	☐ High	☐ Medium	☐ Low	☐ Very low					
31	From your point of view : (Tenants) Readiness and Support degree of to use smart building systems in the units (apartments/shops/offices/..etc.)?	☐ Very high	☐ High	☐ Medium	☐ Low	☐ Very low					
32	The importance degree to provide a clear road map (strategy) for the implementation stages of applying smart buildings standards in Emirates of Dubai?	☐ Very important	☐ Important	☐ neutral	☐ Not important	☐ Not important at all					
33	Do you agree that providing smart building systems should be mandatory?	☐ Yes	☐ No	☐ Other, specify :							
34	Do you agree that providing all smart systems should be a condition in order issue smart building certificate ?	☐ Yes	☐ No	☐ other, specify :							

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35	To what extent you think that the worldwide visions for future buildings are headed towards providing smart systems in the buildings ?	☐ Very high	☐ High	☐ Medium	☐ Low	☐ Very low
36	From your point of view : Do you think that Manufacturers and suppliers in the local market are prepared and have the experience needed in case of implementing smart buildings standards on all future buildings in the emirates of Dubai ?	☐ Yes	☐ No	☐ Other, specify :		
37	Specify the importance degree for installing smart building systems categorized by building type : kindly arrange from 1 to 9 , where (1: is the most important, 9 : is the least important)	☐ In Governmental and Public Buildings only	☐ In Multi storey Building / Residential Apartments only	☐ In Multi storey Building / Offices only	☐ In Commercial Buildings only	☐ In Hotel Buildings only
		☐ In Buildings with health usage (hospitals) only	☐ In private Villas only	☐ In investment Villas only	☐ In industrial Buildings only	
38	Do you agree that implementing smart building systems should be on phases if your answer was yes, kindly categorize the systems in two phases ? (fill the (system #) only in each phase)	☐ Yes ☐ No	1/ Data and communication infrastructure and Networks	2/ Energy Control Systems (Smart HVAC and Lighting)	3/ Security system CCTV	4/ Health and Environment control system (AIR quality)
		Phase 1 :	6/ Smart Devices control (printers, TV, Screens , fridge, washing Machine)	7/ Smart Fire fighting and Public Safety (Civil defence systems)	8/ Smart Building Management System IBMS and zones control	9/ Smart Parking and occupation systems
		Phase 2 :				
	Smart Building Systems and Standards - Cost Analysis and Support Degree					
39	Do you think that the cost of smart building systems is accepted compared with the specifications and benefits provided by implementing it ?	☐ Yes	☐ No	☐ Other, Specify:		
40	Do you think that implementing smart building systems will result to financial savings for the building occupants and users?	☐ Yes	☐ No	☐ Other, Specify:		
41	Do you think that implementing smart building systems will provide happiness for the building occupants and users?	☐ Yes	☐ No	☐ Other, Specify:		

42	The impact of providing smart building systems on the owners and developers satisfaction degree on buildings:	☐ Very high	☐ High	☐ Medium	☐ Low	☐ Very low
43	The impact of providing smart building systems on the tenants satisfaction degree on rented units:	☐ Very high	☐ High	☐ Medium	☐ Low	☐ Very low
44	The impact of providing smart building systems on the total building Cost is :	☐ Very high	☐ High	☐ Medium	☐ Low	☐ Very low
45	The impact of providing smart building systems on the rental value of the buildings :	☐ Very high	☐ High	☐ Medium	☐ Low	☐ Very low
46	Do you have any suggestions or recommendations regarding implementing (smart buildings standards) in Emirates of Dubai ?	☐ No	☐ Yes , Specify :.....			

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Appendix A-2 Final Survey

2016 ID 2014126093

Dubai Smart Buildings -Survey

Smart Building is a building provided with integrated and automated systems that can be controlled (manually or automatically) and monitored through ICT (Tablets, PC's and Mobile Applications) for all or some Building Systems such as (HVAC, Lightening, Access and security, occupation control, etc.), to provide Human comfort and reduce energy consumption and monitor all building operations, this survey is a part of academic research aims to specify Smart buildings **Guidelines** , explore and analyze the implementation process for the smart building systems' , what could be (applicable, mandatory or optional) and the implementation phases.

*Your responses to this survey will be kept confidential.

Thank you in advance for your cooperation

Bio Information:-

1) Your professional role :

☐ Architect	☐ Technical	☐ Sales
☐ Mechanical engineer	☐ Interior designer	☐ IT
☐ Electrical engineer	☐ Project manager	☐ Developer
☐ Civil / Structural engineer	☐ Manufacturer	☐ Owner

2) Your Organization Classification:

- ☐ Govermental Sector
- ☐ Private Enineering Sector(Consultant)
- ☐ Private Enineering Sector(Contractor)
- ☐ Smart Buildings Systems Vendors (Specialist Companies)
- ☐ Buildings Systems Vendors/suppliers
- ☐ Developer/Investor

3) Years of Experience:

☐ 0-4 ☐ 5-10 ☐ 10 or more

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Knowledge Level:-

4) Your knowledge about Smart Building Systems:
☐ High ☐ Medium ☐ Low ☐ NA

5) Have you ever used Smart Building Systems &Guidelines in any of your projects previously:
☐ Yes ☐ No

6) If yes, the motivators of implementing smart building systems & guidelines in your projects were for : (Mark all that apply)
☐ Governmental Requirements ☐ Owner/Client Requirements
☐ Developers Requirements ☐ Achieving Buildings Ocuppants' Comfort
☐ Reducing Buildings Initial Cost ☐ Reducing Buildings Running Cost
☐ Adopting future engineering development and new technologies
☐ Increasing efficiency and effectiveness of building systems

7) **No. of projects** (you have been actively involved in) where smart Building systems were installed :
☐ 0 ☐ 1-3 ☐ 4-6 ☐ 7 or more

Significance of Smart Building Guidelines:-

8) Importance of providing Building with Smart Systems:
(Rating from **1: Not Important at all** to **5: Very Important**)
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

9) Importance of Issuing Smart Building Guidelines :
(Rating from **1: Not Important at all** to **5: Very Important**)
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

10) Importance of Issuing Smart Building Regulations (to be implemented mandatory) :
(Rating from **1: Not Important at all** to **5: Very Important**)
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

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11) From your point of view, Issuing Smart Building Guidelines is the responsibility of:

- ☐ Governmental Regulator
- ☐ Smart Buildings systems (Vendors/ Manufacturers)
- ☐ Private Engineering Sector (Consultants)
- ☐ Developers

Smart Building Guidelines Implementation & Phases:-

12) The importance of providing clear road map of the implementation phases of applying smart Building Guidelines in the Emirate of Dubai:
(Rating from **1: Not Important at all** to **5: Very Important**)

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

13) Do you think that Implementing Smart Building Guidelines will improve (efficiency and effectiveness) of the Building systems:

☐ Yes ☐ No ☐ Neutral

14) Evaluate the Importance of installing Smart Building Systems in each Building type below:

	1:Not Important at all	2:Not Important	3:Neutral	4:Important	5:Very Important
Private Villas	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Investment Villas	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Residential Buildings	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Offices Buildings	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Commercial Buildings (shops & Showrooms)	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Governmental Buildings	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Public Buildings*	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Educational Buildings	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Hospitals and Medical Centers	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Hotels and Hotel Apartment's	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Airports	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Industrial Buildings	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

*Public Buildings: includes (Shopping Centers, Mosques, Theaters, Sport Clubs, Metro Stations, Parks, etc).

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15) Select the Smart Building Systems that needs to be provided in each building type/ usage below, in order to have SMART Building Certificate : (Mark all that apply)

Buildings Types & Usages	Smart Building Systems								
	Data Communication Infrastructure , Networks	Smart BMS and zones control	Smart Energy Control Sys. (Smart Lighting + HVAC + Smart Metering)	Health and Environment Control Sys. (Air Quality)	Smart Water Control Sys.	Smart Security Sys.	Smart Fire Fighting and Safety (Fire Fighting Sys.)	Smart Devices Control (printer, TV, Screens..)	Other Smart Systems (Elevators, Central Gas , parking ...)
Private Villas	☐	☐	☐	☐	☐	☐	☐	☐	☐
Investment Villas	☐	☐	☐	☐	☐	☐	☐	☐	☐
Residential Buildings	☐	☐	☐	☐	☐	☐	☐	☐	☐
Offices Buildings	☐	☐	☐	☐	☐	☐	☐	☐	☐
Commercial Buildings (shops & Showrooms)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Governmental Buildings	☐	☐	☐	☐	☐	☐	☐	☐	☐
Public Buildings*	☐	☐	☐	☐	☐	☐	☐	☐	☐
Educational Buildings	☐	☐	☐	☐	☐	☐	☐	☐	☐
Hospitals and Medical Centers	☐	☐	☐	☐	☐	☐	☐	☐	☐
Hotels and Hotel Apartment's	☐	☐	☐	☐	☐	☐	☐	☐	☐
Airports	☐	☐	☐	☐	☐	☐	☐	☐	☐
Industrial Buildings	☐	☐	☐	☐	☐	☐	☐	☐	☐

*Public Buildings: includes(Shopping Centers, Mosques, Theaters, Sport Clubs, Metro Stations, Parks, etc).

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Cost & Impact of Smart Building Systems :-

(From your point of view)

16) Cost of installing smart Building systems in Building is the responsibility of:

☐ Buildings Owners ☐ Tenants ☐ Both

17) Residential units (Owners'/Tenants') responsibility is limited to provide the following: (Mark all that apply)

☐ Wi-Fi (internet Network)
☐ Smart Data and Communications Networks and it's requirements
☐ Infrastructure and cables
☐ Smart Sensors
☐ Smart Meters
☐ Smart Switches

18) Implementing Smart Building Systems and Guidelines will result in benefits for :(Mark all that apply)

☐ Owners/ Developers/Investors ☐ Tenants and Occupants
☐ Buildings Operators ☐ Vendors and manufacturers
☐ Govermental Regulators

19) Installing smart Building systems - Cost will be approximately:

☐ 0 - 5% of the total Building Cost
☐ 6-10% of the total Building Cost
☐ 11-25% of the total Building Cost
☐ Above 30% of the total Building Cost

20) Do you think that market cost of installing Smart Building Systems is acceptable compared to the resulting benefits:

☐ Yes ☐ No ☐ Neutral

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21) The impact of installing smart Building systems on the **Rental Value** of the Building :
(Rating from **1: very low** to **5: Very High**)

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

22) Owners & Occupants **Satisfaction Degree** of installing smart building systems:
(Rating from **1: very low** to **5: Very High**)

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

23) The positive impact of installing smart Building systems on the **Comfort** of the occupants:
(Rating from **1: very low** to **5: Very High**)

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

24) The positive impact of installing smart Building systems on the **Happiness** of the occupants:
(Rating from **1: very low** to **5: Very High**)

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

25) The positive impact of installing smart Building systems on the **Health** of the occupants:
(Rating from **1: very low** to **5: Very High**)

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

26) Any suggestions or recommendations regarding developing (Smart Building Guidelines) in the Emirate of Dubai that you would like to add:

.....
.....
.....
.....
.....
.....

Thank You for your Valuable information

***Contact information (Optional):**

Name: _____

Email: _____

Mobile/Phone: _____

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Appendix A-3 Sample of Survey Results

2016 ID 2014126093

Dubai Smart Buildings -Survey

Smart Building is a building provided with integrated and automated systems that can be controlled (manually or automatically) and monitored through ICT (Tablets, PC's and Mobile Applications) for all or some Building Systems such as (HVAC, Lightening, Access and security, occupation control, etc.), to provide Human comfort and reduce energy consumption and monitor all building operations, this survey is a part of academic research aims to specify Smart buildings **Guidelines** , explore and analyze the implementation process for the smart building systems' , what could be (applicable, mandatory or optional) and the implementation phases.

*Your responses to this survey will be kept confidential.

Thank you in advance for your cooperation

Bio Information:-

1) Your professional role :

☐ Architect	☐ Technical	☐ Sales
☐ Mechanical engineer	☐ Interior designer	☐ IT
☐ Electrical engineer	☐ Project manager	☐ Developer
☑ Civil / Structural engineer	☐ Manufacturer	☐ Owner

2) Your Organization Classification:

☐ Governmental Sector
☑ Private Enineering Sector(Consultant)
☐ Private Enineering Sector(Contractor)
☐ Smart Buildings Systems Vendors (Specailist Companies)
☐ Buildings Systems Vendors/suppliers
☐ Developer/Investor

3) Years of Experience:

☐ 0-4 ☑ 5-10 ☐ 10 or more

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Knowledge Level:-

4) Your knowledge about Smart Building Systems:
☐ High ☑ Medium ☐ Low ☐ NA

5) Have you ever used Smart Building Systems &Guidelines in any of your projects previously:
☐ Yes ☑ No

6) If yes, the motivators of implementing smart building systems & guidelines in your projects were for : (Mark all that apply)
☐ Governmental Requirements ☐ Owner/Client Requirements
☐ Developers Requirements ☑ Achieving Buildings Occupants' Comfort
☐ Reducing Buildings Initial Cost ☑ Reducing Buildings Running Cost
☑ Adopting future engineering development and new technologies
☑ Increasing efficiency and effectiveness of building systems

7) **No. of projects** (you have been actively involved in) where smart Building systems were installed :
☑ 0 ☐ 1-3 ☐ 4-6 ☐ 7 or more

Significance of Smart Building Guidelines:-

8) Importance of providing Building with Smart Systems:
(Rating from **1: Not Important at all** to **5: Very Important**)
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☑ 5

9) Importance of Issuing Smart Building Guidelines :
(Rating from **1: Not Important at all** to **5: Very Important**)
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☑ 5

10) Importance of Issuing Smart Building Regulations (to be implemented mandatory) :
(Rating from **1: Not Important at all** to **5: Very Important**)
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☑ 5

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11) From your point of view, Issuing Smart Building Guidelines is the responsibility of:

- ☑ Governmental Regulator
- ☐ Smart Buildings systems (Vendors/ Manufacturers)
- ☐ Private Engineering Sector (Consultants)
- ☐ Developers

Smart Building Guidelines Implementation & Phases:-

12) The importance of providing clear road map of the implementation phases of applying smart Building Guidelines in the Emirate of Dubai:
(Rating from **1: Not Important at all** to **5: Very Important**)

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☑ 5

13) Do you think that Implementing Smart Building Guidelines will improve (efficiency and effectiveness) of the Building systems:

☑ Yes ☐ No ☐ Neutral

14) Evaluate the Importance of installing Smart Building Systems in each Building type below:

	1:Not Important at all	2:Not Important	3:Neutral	4:Important	5:Very Important
Private Villas	☐ 1	☑ 2	☐ 3	☐ 4	☐ 5
Investment Villas	☐ 1	☐ 2	☑ 3	☐ 4	☐ 5
Residential Buildings	☐ 1	☐ 2	☐ 3	☑ 4	☐ 5
Offices Buildings	☐ 1	☐ 2	☐ 3	☑ 4	☐ 5
Commercial Buildings (shops & Showrooms)	☐ 1	☐ 2	☐ 3	☑ 4	☐ 5
Governmental Buildings	☐ 1	☐ 2	☐ 3	☐ 4	☑ 5
Public Buildings*	☐ 1	☐ 2	☐ 3	☐ 4	☑ 5
Educational Buildings	☐ 1	☐ 2	☐ 3	☐ 4	☑ 5
Hospitals and Medical Centers	☐ 1	☐ 2	☐ 3	☐ 4	☑ 5
Hotels and Hotel Apartment's	☐ 1	☐ 2	☐ 3	☑ 4	☐ 5
Airports	☐ 1	☐ 2	☐ 3	☐ 4	☑ 5
Industrial Buildings	☐ 1	☐ 2	☑ 3	☐ 4	☐ 5

*Public Buildings: includes (Shopping Centers, Mosques, Theaters, Sport Clubs, Metro Stations, Parks, etc).

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15) Select the Smart Building Systems that needs to be provided in each building type/ usage below, in order to have SMART Building Certificate : (Mark all that apply)

Buildings Types & Usages	Smart Building Systems								
	Data Communication Infrastructure , Networks	Smart BMS and zones control	Smart Energy Control Sys. (Smart Lighting + HVAC + Smart Metering)	Health and Environment Control Sys. (Air Quality)	Smart Water Control Sys.	Smart Security Sys.	Smart Fire Fighting and Safety (Fire Fighting Sys.)	Smart Devices Control (printer, TV, Screens..)	Other Smart Systems (Elevators, Central Gas , parking ...)
Private Villas	☑	☐	☐	☐	☑	☑	☑	☐	☐
Investment Villas	☑	☐	☑	☑	☑	☑	☑	☐	☑
Residential Buildings	☑	☐	☑	☑	☑	☑	☑	☐	☑
Offices Buildings	☑	☐	☑	☑	☑	☑	☑	☑	☑
Commercial Buildings (shops & Showrooms)	☑	☐	☑	☑	☑	☑	☑	☐	☑
Governmental Buildings	☑	☑	☑	☑	☑	☑	☑	☑	☑
Public Buildings*	☑	☑	☑	☑	☑	☑	☑	☑	☑
Educational Buildings	☑	☐	☑	☑	☑	☑	☑	☐	☑
Hospitals and Medical Centers	☑	☑	☑	☑	☑	☑	☑	☑	☑
Hotels and Hotel Apartment's	☑	☑	☑	☑	☑	☑	☑	☑	☑
Airports	☑	☑	☑	☑	☑	☑	☑	☑	☑
Industrial Buildings	☑	☑	☑	☑	☑	☑	☑	☑	☑

*Public Buildings: includes(Shopping Centers, Mosques, Theaters, Sport Clubs, Metro Stations, Parks, etc).

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Cost & Impact of Smart Building Systems :-

(From your point of view)

16) Cost of installing smart Building systems in Building is the responsibility of:

☐ Buildings Owners ☐ Tenants ☑ Both

17) Residential units (Owners'/Tenants') responsibility is limited to provide the following: (Mark all that apply)

☑ Wi-Fi (internet Network)
☑ Smart Data and Communications Networks and it's requirements
☑ Infrastructure and cables
☑ Smart Sensors
☑ Smart Meters
☑ Smart Switches

18) Implementing Smart Building Systems and Guidelines will result in benefits for :(Mark all that apply)

☐ Owners/ Developers/Investors ☑ Tenants and Occupants
☑ Buildings Operators ☐ Vendors and manufacturers
☑ Govermental Regulators

19) Installing smart Building systems - Cost will be approximately:

☐ 0 - 5% of the total Building Cost
☑ 6-10% of the total Building Cost
☐ 11-25% of the total Building Cost
☐ Above 30% of the total Building Cost

20) Do you think that market cost of installing Smart Building Systems is acceptable compared to the resulting benefits:

☑ Yes ☐ No ☐ Neutral

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21) The impact of installing smart Building systems on the Rental Value of the Building :
(Rating from **1: very low** to **5: Very High**)

☐ 1 ☐ 2 ☑ 3 ☐ 4 ☐ 5

22) Owners & Occupants Satisfaction Degree of installing smart building systems:
(Rating from **1: very low** to **5: Very High**)

☐ 1 ☐ 2 ☐ 3 ☑ 4 ☐ 5

23) The positive impact of installing smart Building systems on the Comfort of the occupants:
(Rating from **1: very low** to **5: Very High**)

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☑ 5

24) The positive impact of installing smart Building systems on the Happiness of the occupants:
(Rating from **1: very low** to **5: Very High**)

☐ 1 ☐ 2 ☐ 3 ☑ 4 ☐ 5

25) The positive impact of installing smart Building systems on the Health of the occupants:
(Rating from **1: very low** to **5: Very High**)

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☑ 5

26) Any suggestions or recommendations regarding developing (Smart Building Guidelines) in the Emirate of Dubai that you would like to add:

N/A :

Thank You for your Valuable information

***Contact information (Optional):**

Name: _____

Email: _____

Mobile/Phone: _____

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