International Journal of Engineering Research and Technology. ISSN 0974-3154, Volume 13, Number 12 (2020), pp. 5440-5450

Comparative Analysis Between Smart Buildings Projects (SBP) in Egypt and Worldwide

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Abstract

The world is changing, adaptation is no more a choice; if we are going to move into the future with intelligent progression; architecture must be more responsible and buildings must be smarter in order to cope with future demands. It is essential to consider all scales of data and focus on the methodology of designing future buildings to be of a holistic, sustainable and smart system. The smart features of smart buildings projects (SBP) are not clear; they differ from one project to another and from one country to another; also there is lack of research work that is concerned with this important type of buildings in Egypt. This research aims at comparing between features of smart buildings projects (SBP) in Egypt and worldwide. The objective of the paper was fulfilled first; through analysis of literature sources and second; through preliminary analysis of five international SBP and five SBP in Egypt. Finally; a comparison was conducted between the smart features of the ten analyzed SBP.

Keywords: Smart Buildings Projects, Smart Cities, Egypt.

1. INTRODUCTION

Although the concept of smart buildings projects (SBP) evolved in 1981; the definition of SBP is still vague [1]; the aim and concept of SBP are not clear as well, they differ from one country to another. Asia, Europe and Australia are considered pioneer continents in the field of SBP. Asia mainly concentrates on environmental aspects; the Asian Institute of Intelligent Building determined 10 quality environmental modules to define and assess SBP [2]. In Europe; the main target is to improve the European economy by achieving low-carbon economy goals through adopting smart cities and smart buildings [3]. Australia focuses on increasing the performance of environmental, economic, operation and safety aspects in addition to improving the performance and reliability of various technologies in communications, control, automation, etc. [4]. A comprehensive set of smart features is needed to distinguish between smart and conventional buildings. This set will also facilitate making proper decisions during early project phases by selecting the most suitable smart features.

1.1 Research Problem and Objective

Over the last three decades; many institutes all over the world conducted many studies and researches trying to extract a definition to Smart Buildings Projects (SBP) and determine their concepts and targets; however, the definition of SBP is still vague [1]. The aim and concept of SBP are not clear as well, they differ from one country to another according to time, needs and culture.

The entire research shed light on a main problem that is demonstrated in vague features of SBP; this is in addition to lack of research work that is concerned with this important type of buildings. The main objective of the current research is to identify the key smart features of SBP.

2. METHOD

The objective of the paper was fulfilled first; through analysis of literature sources and second; through analysis of five international case studies. Finally; a comprehensive set of smart features was concluded and translated into smartness checklist. Figure 1 represents the flow of research methods in terms of input, process and output.

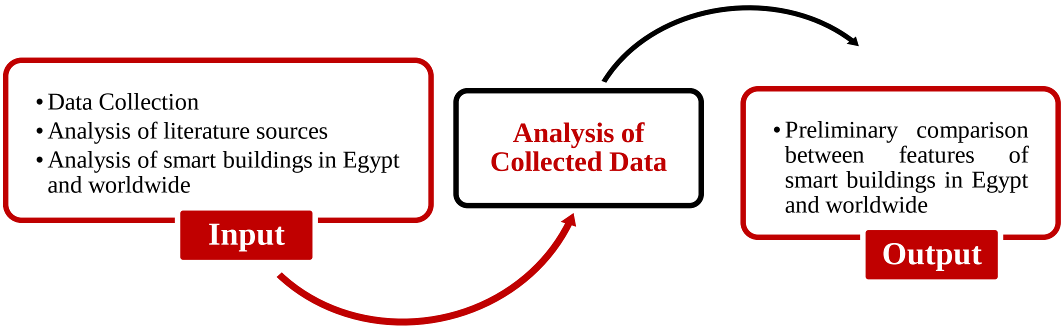

Fig. 1. Method of Fulfilling the Objectives of the Paper

3. LITERATURE REVIEW

A.H. Buckman et al. [1] aimed at assessing the existing meaning of Intelligent Buildings and extracting a new successful definition for Smart Buildings. This definition aims at reflecting more advanced criteria, targets and guidelines that exceed limitations of previous terminology, in addition to meeting the criteria of assessing high-performing buildings. This was achieved through focusing on and analyzing the key drivers behind SBP development from past to present. Albert T.P. So et al. [5] developed a new method for defining and specifying intelligent buildings; they categorized the users' requirements into eight key modules and they divided the buildings' features and systems into ten elements. Each group of elements was then assigned to a particular key module; and each type of building is then allocated certain key areas for detailed design.

So Albert and Wong KG [2] analyzed the available definitions of SBP and defined a comprehensive method of assessing intelligent buildings which they called the Intelligent Building Index (IBI). The IBI consists of different quality environment modules; each module has different score and rank; based on the rank, the intelligent building is assessed and the overall performance is determined. The key elements of each module are flexible depending on the practice of the country where the intelligent building is being built or assessed. I. Batova Eugeny [6] discussed the problem of vague definitions of SBP and misunderstood to building intelligence as building automation only. The target of the research was to measure the intelligence of SBP using a simulation of building operation. The paper presented a theoretical equation to measure intelligence of a building and to differentiate between intelligence and automation; however; this equation is not accurate as it doesn't include environmental changes and inhabitants activities. The way of using the extracted equation is not clear; application on a case study was essential to facilitate using the equation and assessing its impact on measuring the intelligence of SBP.

Fratu Mariana and Fratu Aurel [7] focused on a main problem that is demonstrated in ignorance of benefits of SBP due to lack of research work and challenges that may face the designers while trying to incorporate new technologies to design efficient integrated SBP. The research introduced virtual prototyping as a flexible method to face the challenges of SBP and to help owners and designers making suitable decisions throughout the life cycle of SBP. The proposed method is very beneficial as it provides several what-if scenarios and alternatives to select the optimum decision in order to achieve the targets of SBP which differs from one project to another and from one owner to another. Iwuagwu Ben Ugochukwu and Iwuagwu Margaret Chioma Ben [8] studied the challenges of adopting SBP in Nigeria. The main target of the paper was emphasizing the benefits of applying concepts of SBP in Nigeria and proposing some recommendations and solutions to face the challenges that face this type of projects. The research is very important as it reflects the status of SBP in Africa. The mentioned challenges, benefits and proposed recommendations are very important to the current research and should be considered while designing a framework to manage SBP in Egypt.

Quan Jin and Holger Wallbaum [9] discussed a problem that is demonstrated in the gap between perception of users and key performance indicators in SBP. The main objective of the paper is improving human health and wellbeing in indoor environments of SBP, in addition to achieving low environmental impact and high economic performance through the building life cycle. In order to cancel or at least decrease the gap between perception of users and key performance indicators of SBP; the research highlighted the importance of utilizing circular design process that involves all the stakeholders through the life cycle of building instead of the conventional linear design. The research also identified three main characteristics that should be achieved in SBP; health and wellbeing, low energy use based indoor environmental design and real time response to human demands. The research shed light on the gap between perception of users and key performance indicators of SBP; this challenge will be considered while analyzing the case studies of SBP in Egypt in order to stand on the key challenge and provide appropriate solutions.

Matthew B.Hoy and Tara J. Brigham [10] analyzed the concepts of SBP aiming to assess the impact of applying concepts of SBP on libraries buildings. The research pointed out some examples of SBP technologies, but it didn't illustrate clearly the implications of the mentioned technologies on libraries buildings. The main target of the paper wasn't successfully fulfilled; however; the current research can benefit from the stated definitions and concepts of SBP. Ćetković Alexander [11] discussed the problem of keeping the user away from the design process of SBP; this makes the SBP not so smart or intelligent. From the author's point of view; smartness of a building depends on how smart the users see the building. The author highlighted the importance of involvement of users during early project phases as the smartness of building is determined based on how the users see it smart. On the other hand; the author's point of view is that the words "interactive architecture" and "adaptive architecture" should replace the word smart or intelligent when used by architects. The current research will adopt the word "Smart"; this word is more flexible and will be covering intelligent building, interactive architecture and adaptive architecture; while involvement of users can be adopted as a method to face challenges of SBP.

O. Omar [12] focused on a main problem that is demonstrated in the lack of framework that reflects the characteristics, design guidelines and parameters of SBP. The main target of the research was to proposing a selection criteria and decision making tool to SBP; this was fulfilled through analysis of literature sources. The research is a good attempt to categorize SBP through two approaches; the first is a multi-criteria framework that illustrates and defines the design process' involved factors; the second is a conceptual environmental framework helps in limiting the carbon dioxide emissions. The research presented the two frameworks as criteria selection tools to SBP while it missed the impact of integrating the two frameworks to provide a comprehensive framework which is capable of facing the challenges of SBP. The paper discussed SBP in general and not in specific location. Mushatat Sabah et al [13] discussed the problem of the vague role of smart buildings to achieve sustainability. The research applied a systematic qualitative review approach in order to identify a definition of sustainable development and use it to assess the technological impact of smart buildings on the environmental, economic and social aspects. Based on this review and analysis; the research highlighted the good impacts of smart buildings; this includes lower energy and water consumption, operational costs; increase in productivity and investments and thus, achieving sustainability. The study is very beneficial; it identified the attributes of smart and sustainable practices in buildings and illustrated the overlap between the two aspects. The study also shed light on the importance of integration between smart and sustainability to achieve more efficient buildings.

D.E. Khater, [14] discussed the problem of absence of smart project management framework to manage sustainable housing. The study concentrated on the importance of amending the project management process of conventional building in order to cope with requirements of smart buildings. The research incorporated the green principles into the process of project management; the main aim is to develop a comprehensive framework for green project management of housing projects. Finally; the study proposed a formula and framework that can be implemented to achieve sustainable project management for green housing.

3.1 Concluding Remarks

Based on the analysis of literature sources some concluding remarks were pointed out as follows:

- The analyzed researches do not provide holistic understanding for the concept of SBP.
- Objectives of SBP are not constant; they differ from one place to another and from one SBP to another.
- Although there are many worldwide attempts to define SBP; characteristics of SBP were only illustrated and highlighted in Europe, Asia and Australia.
- The difference between sustainable buildings and SBP is not clear, sustainable buildings and SBP are the same.
- In Egypt; there is lack of studies that are concerned with SBP in general.

4. WORLDWIDE EXPERIENCE

Five international smart buildings were analyzed in order to stand on the main smart features and characteristic of SBP. The analyzed buildings were selected based on the following:

a) Significant buildings SBP that were recommended by SBP experts.
b) Analysis of researches that are concerned with this type of buildings.
c) Preliminary research to collect data related to SBP in some continents that were not covered in the two previous points.
d) Towers were excluded from the study as they are considered special types of buildings.

4.1 The Edge Office Building

The Edge Office Building shown in Fig. 2 is located in Amsterdam, Netherlands, Europe. It is known as the smartest building in the world. The area of the building is 40,000 m^2. The construction cost of the building is 84,000,000 USD.

Fig. 2. The Edge Office Building [15]

The main features of the building are as follows [15]:

International Journal of Engineering Research and Technology. ISSN 0974-3154, Volume 13, Number 12 (2020), pp. 5440-5450

- The Edge was built with the IoT as its main concept.
- The Edge adopted IoT instead of BIM in order to achieve automatic energy performance visualization, post occupancy monitoring and energy analysis.
- Low energy, operation and maintenance costs.
- Higher productivity and less sick leave; thus, better financial performance.
- Less construction materials and lower costs.
- The building's orientation is considered; each facade is designed and treated according to its orientation and purpose
- Smart Lighting, Solar panel roof, Energy reuse, Rain water reuse, Thermal energy storage, Light over Ethernet, Mobile app-personalized workspaces and Ecological corridor
- The building's operations and work environment is managed through huge amount of data generated by the building's digital systems and the mobile app on everything from energy use to working patterns.
- Hot desking concept has been adopted where 2,500 workers share 1,000 desks.
- Coordination between designers, contractors, operators, users and all stakeholders has been considered during early design phases of the project.
- A new lighting fixture with embedded sensors for motion, temperature, light and air and connected to the internet was created.
- Edge has used three virtual dimensional models to build its demonstration of smart technologies.
- Heat map visualization; this helps users to understand the volume of people in any zone within the building at a given time.
- Edge provides safer built environment through integrating strategies for emergency response and public announcement systems.

4.2 Apple Park Office Building "Spaceship Headquarters"

Apple Park Office Building which is known as The Spaceship Headquarters is represented in Fig. 3. Apple Park Office Building is located in Cupertino, California, USA. The area of the building is 260,000 m^2. The construction cost is 5,000,000, 000 USD.

Fig. 3. Apple Park Office Building "Spaceship Headquarters" [16]

The main features of the building are as follows:

- Circular office building with universal space.
- The air conditioning of the building is used for three months only as the "breathe" concept is used for the design of concrete for floors and ceilings; design to breathe concept means that concrete for floors and ceilings has efficient air ventilation features within its solid materials.
- Saving cooling and heating costs[16]
- Minimize use of potable water by using recycled water[17]
- The building faces safety issues during operations; the space is overflowing with glass panels with no marks evening work spaces, many employees get distracted and smack into the glass and get injured [18].
- Camera surveillance along the perimeter fence of the building is monitored through centrally-located campus operations center; this is in addition to drones that are always flying over the campus to secure it and the surroundings [19].
- Facade are being cleaned by cleaning spider boom, no facade cleaning systems are installed on facades [20].
- The building runs 100% on renewable energy; 700,000 solar panels which provide about 50% of the needed energy are installed on the roof top of the main building and garages; the rest of required energy is provided through offsite solar farms [21].
- The building is not certified as a green or eco-friendly building; however; 95% of the concrete in buildings and paved ways from the original HP headquarters were recycled and reused in this building; and all concrete debris were recycled onsite.

4.3 Pixel Smart Building

Pixel Smart Building shown in Fig. 4 is considered the most successful building to achieve characteristics of SBP in Melbourne; Australia. The area of the building is 1,137m^2. The construction cost of the building is 4,300, 000 USD.

Fig. 4. The Pixel Building [22]

The main features of the building are as follows [22]:

- The building achieved 105 Green Star points and 105 LEED points.
- Pixel is the first carbon neutral office building in Australia that generates all its own power and water on site.
- Pixel’s colorful façade is significant and creates a unique identity to the building; it is made of zero waste recycled color panels that provide daylight, shade, views and control glare.
- Pixel introduced a significant example of ‘Future Office' that should be adopted when a carbon constrained environment demands a greater focus on energy efficiency.
- Pixel introduces an assessment of new technologies impact on the commercial building sector.
- Pixel installed grey water treatment system; this helps providing personal greenery to each office floor.

4.4 Princess Nora Bint Abdulrahman University (PNU)

Princess Nora Bint Abdulrahman University (PNU) shown in Fig. 5 is located in Riyadh, KSA; Asia. The area of the building is 3,000,000 m^2. The construction cost of the building is 13,000, 000,000 USD [23].

Fig. 5. The Princess Nora Bint Abdulrahman University [25]

The main features of the building are as follows:

- LEED Gold, friendly green campus has 600 smart buildings - Reduce carbon footprint by 125,000,000 kg of CO_2.
- Solar panels of 36,305 m^2 area provide 25.4 MWth heat for the university and reduce harmful emissions; they saving 52,000,000 liters of diesel throughout their life cycle compared to conventional heating systems. Solar panels have great impact on cost savings based on 3 main aspects; initial cost, lifetime and performance.
- Energy efficient facade provides over 19% energy reduction and 13% reduction in the total heat gain of buildings envelope; this saves cooling costs and lighting costs [24].
- Running services of the hospital are connected; this includes infrastructure, facilities management support services and overseeing the delivery and smooth operation of all clinical services [25].
- Connectivity is achieved through the campus; the campus is monitored and controlled by CCTV System (1600+ cameras), Access Control, Security and Access Control Server for the whole campus, Integrated BMS and Large command center [26].

4.5 Verde Hotel

Verde Hotel shown in Fig. 6 is located in Cape Town, South Africa. The area of the building is 13,000 m^2. The construction cost of the building is 11,000,000 USD; 1,200,000 USD of investment were allocated to sustainable interventions of the hotel.

Fig. 6. Verde Hotel [28]

Verde hotel focused on the concept of “Thrivability”; “thrivability is about succeeding and it covers the three core values of the triple bottom line: people, profit and planet” [27].

Verde Hotel has been awarded the following certificates [27]:

-5 Star Master Builder Association Certification; 2013.
-Water Conservation and Recycling best implementation and practice certification by Cape Town City; 2014.

-LEED Platinum for New Construction; 2014.
-Six Green Star SA Existing Building Performance Certification; 2015
-LEED Platinum for Existing Building Operation and Maintenance; 2015.

The main features of the building are as follows [28]:

- Energy Efficiency:
  - o Energy is generated through 220 photovoltaic panels on roof and northern façade.
  - o Three wind turbines
  - o Installation of regenerative elevators where elevators generate energy while braking and save 30% of usual consumed energy.
  - o Installation of gym equipment that generate energy
  - o Heat pumps and ground loops cooling/heating system
  - o Adopting passive design strategies to achieve extra energy efficiency
  - o Energy-efficient LED lights
  - o Installation of double glazed windows
  - - Incentives:
  - o Guests are rewarded by Verdinos which is an in-house currency earned for being involved in the building's sustainability and green choices.
  - o Guests receive a certificate proving that the carbon created by their stay has been offset
  - o Providing priority parking for guests driving electric/hybrid/car pool vehicles.

- Sustainable Design:

o Building energy model is used to get optimized design
o Adopting socially responsible carbon neutral systems.
o Intelligent building management system to monitor consumption of energy and resources.
o Efficient, intelligent heating ventilation and air-conditioning system
o Responsible, healthier, rapidly renewable, recycled and eco-friendly products used where feasible; this includes the following:
▪ Paints, coatings, adhesive and sealants with low volatile organic compound concentrations
▪ Carpets made of renewable wool, recycled tires and old carpets

- Water Saving:

o Grey-water recycling system to save water.
o Rainwater is collected to be used for irrigation.
o Installing low-flow fittings on all taps and shower heads
o Sub-soil drainage water used for irrigation, car-washing and external cleaning.

- Decreasing Waste:

o Minimizing and preventing waste through new policies and strategies
o Reusing, recycling and composting strategies
o Avoid packaging
o Composting food waste

- Green Conferences:

o Using separate bins for items that can be recycled or composted
o Eco-friendly stationery, recycled paper, carbon-neutral printer
o Chalkboards to eliminate the need for energy or paper use
o Natural lighting
o Energy-efficient air conditioning, lighting and technology

5. EXPERIENCE IN EGYPT

Five smart buildings in Egypt were analyzed in order to stand on the main smart features and characteristic of SBP. The analyzed buildings were selected based on the following:

a) Significant buildings SBP that were recommended by SBP experts.
b) Analysis of researches that are concerned with this type of buildings.
c) Preliminary research to collect data related to SBP in Egypt that were not covered in the two previous points.
d) Towers were excluded from the study as they are considered special types of buildings.

5.1 Dar Headquarters

Dar office building in Smart Village; Egypt is shown in Fig. 7. Area of the building is 42,300 m2, the construction cost is 100,000,000 USD and the monthly operating cost is 70,000 USD approximately.

Fig. 7. Dar Headquarters [29]

The features of the building were pointed out as follows [29]:

- Located in smart village which is considered the first smart city high-tech office park in Egypt.
- Achieved LEED Gold for construction
- Targeting LEED Gold for operation and maintenance
- The rooftop space is covered with 1000 SM of photovoltaic panels that gather solar energy and supply about 5% of total building energy requirements.
- A large glass atrium that draws in natural light from both the interior and exterior perimeter walls. This atrium is designed as a thermal buffer between the exterior climate and the conditioned climate of the building.
- 18 m2 of operable skylight in the atrium roof provided to

accommodate the passive smoke evacuation system

- Combined sustainable strategies result in an approximate 30% energy reduction
- Water efficiency for both internal building use and irrigation use.
- Day lighting sensors to control office space lighting. Lights automatically shut off in areas where natural light is sufficient.
- Facility management system that was introduced during testing and commissioning phase.
- Computerized asset management system
- BMS and CCTV to manage and control the systems of the building and keep it safe.
- Electronic access control
- The monthly operating costs of the building represent 0.07% of the total construction cost.

5.2 ECG Premises

ECG Premises in Smart Village; Egypt is shown in Fig. 8. Area of the building is 15,540 m2, the construction cost is 4,640,000 USD and the monthly operating cost is 38,000 USD approximately.

Fig. 8. ECG Premises [30]

The features of the building were pointed out as follows [31]:

- The building has two water supplying sources, potable water in addition to grey water which is used for planting.
- Double glazing and tinted glass to minimize cooling loads.
- Fire extinguishing system that is linked to Building Automation System (BAS).
- Elevators with intelligent traffic optimization system and linked to BAS.
- Security system and CCTV to assure safety of the building
- The monthly operating costs of the building represent 0.8% of the total construction cost.

5.3 Ministry Building

The New Administrative Capital is considered the first attempt to establish a smart city in Egypt; the responsible authorities have identified some guidelines that should be applied on buildings inside the new smart city. Fig.9. represents a ministry building in the new administrative capital.

Fig. 9. Ministry Building in the New Administrative Capital [32]

The main features of this smart building can be pointed out as follows [33]:

- 50% of the roof area of the building must be covered by PV system coated with dust control material of life span not less than 5 years.
- PV system feeds the AC power into the main distribution panel of the building when solar energy is available.
- The building is connected to the Command and Control Center (CCC) which is the main control building monitoring and managing safety and security across the city and overseeing any emergency situation.
- The building is connected to the City Operation Center (COC) which is responsible for managing all the services across the city, monitoring the key performance indicators (KPIs) and ensuring the success of smartness initiatives.
- BMS system covers the main equipment in the buildings.
- Providing comfortable work environment.
- Maximize using local products.
- Optimize construction, operation & maintenance costs.
-

5.4 Bank Premises

Fig.10. represents a bank premises that is located in the financial district within the New Administrative Capital. The building is in final design phase; the area of the building is 65,000 m^2.

Fig.10. Bank Premises, the New Administrative Capital

The main features of the building are as follows [34]:

- Flexible architectural design
- The building is formed of two connected blocks with a combining atrium space that provides day lighting for the office spaces and all common facilities are located within it.
- Optimal building performance.
- Energy efficient building.
- Sustainable green building design.
- Targeting LEED Gold certification.
- 50% of the roof area is covered with PV cells.
- Attain highest value at the lowest possible cost.
- Connected to the COC and CCC of the new administrative capital.
- Connected to the main data center of the new administrative capital.
- All building systems are connected to BMS.
- CCTV to ensure safety inside the building as well as its surroundings.

5.5 Crédit Agricole Egypt Head Office

- Fig.11. represents Crédit Agricole Egypt Head Office located in the 5th settlement, New Cairo, Egypt. The area of the building is 42,000 m2. The construction cost of the building is 50,000, 000 USD.

Fig.11. Crédit Agricole Egypt Head Office [35]

The main features of the building are as follows [36]

- The design and construction of this building is based on the consideration of the triple bottom line: People, Planet and Profit.
- The Head Office depends on rationalizing power resources, in addition to providing maximum comfort to its staff.
- The building provides different facilities to optimize the co-working environment including well-equipped training and meeting rooms and an auditorium that can take up to 300 persons in addition to a cafeteria, a restaurant, a gym and a green area.
- A solar station with a capacity of 200 KWp is installed on the rooftop of the building; this solar station is contributing in the reduction of the bank's energy consumption rate by 7%.
- The building designed to save energy, use less water, generate less waste and provide higher levels of indoor quality and comfort.
- The building is the 1st building in Egypt and North Africa to obtain the platinum LEED certificate by the U.S. Green Building Council iconic design.
- The building aimed at reducing impacts on human health and on the environment through better site selection, construction, operation and maintenance.
- The building has launched the initiative "Go Digital" to rationalize the usage of resources comprising paper reduction through the digitalizing of processes and creating an awareness campaign for the staff; this is in addition to launching the e-statement service to integrate the customers in this initiative in favor of the environment.
- The bank has also applied a new initiative that matches its eco-friendly values which is collect old paper to be delivered to a charity organization, to be recycled into hand made products. The revenue of the sold products will be used to finance people in need to have a better life.

6. CONCLUSION

Based on analysis of the international SBP; the below remarks were pointed out:

1- In Europe; the analyzed SBPs aim at achieving lower energy and operational costs and improving the European economy. European SBP focuses on innovation, adopting sustainability, flexible design and IoT and BIM technologies in order to achieve this aim.

2- In America; SBP is a green and environmental friendly building that concentrates on sustainability aspects and efficient energy performance.

3- In Australia; sustainability and energy performance are the main features of SBP.

4- In Asia; the main smartness aspects of the analyzed SBPs are sustainability, energy efficiency and connectivity with other buildings.

5- In Africa; the analyzed SBP focused on energy efficiency sustainability in addition to innovation and incentives for improving sustainability and making green choices.

6- The construction cost of SBP per m^2 ranges from 20,000 USD to 2000 USD. In Africa; the average construction cost of SBP per m^2 is 500 USD, this might be due to Africa's strategies that encourages reusing old materials and buildings; about 11% of the total construction cost SBP in Africa is allocated to sustainable interventions.

Based on analysis of SBP in Egypt; the below remarks were pointed out:

1- In Egypt; the smart features of SBP are not clear, they differ from one building to another according to the experience of owner, designer and project manager of each project.

2- Sustainability and green buildings and efficient energy performance are the main features of SBPs in Egypt.

3- In addition to sustainability and efficient energy performance; SBPs within Smart Village concentrate on facility management aspects; however; facility management is usually introduced during late project phases.

4- SBPs within the New Administrative Capital SBP focuses on IoT and BIM technologies, this is in addition to saving energy. Facility management is introduced during testing and commissioning phase or after operation.

5- The construction cost of SBP per m^2 ranges from 700 USD to 3000 USD.

The main features of the analyzed SBP were classified into 8 main categories as follows:

1- Cost Savings
2- Efficient Facility Management (Operation and Maintenance, Safety, Comfort, Health, Sanitation, Satisfaction, etc.)
3- Efficient Architectural Design
4- Efficient Energy Performance
5- Internet of Things (IoT) technology, Automation, BIM applications, etc.
6- Accredited Buildings
7- Connectivity
8- Innovation / Incentives

Table (1) compares between the smart features of analyzed SBP in Egypt and worldwide after categorizing them into the above mentioned 8 categories.

Table 1. Comparison between Smart Buildings in Egypt and Worldwide

Project										
	The Edge Office Building	Apple Park Office Building "Spaceship Headquarters"	Pixel Smart Building	Princess Nora Bint Abdulrahman University (PNU)	Verde Hotel	Dar Headquarters	ECG Premises	Ministry Building	Bank Premises	Crédit Agricole Egypt Head Office
Location	Amsterdam, Netherlands, Europe	Cupertino, California, USA	Melbourne; Australia	Riyadh, KSA, Asia	Cape Town, South Africa	Smart Village	Smart Village	New Administrative Capital	New Administrative Capital	5th Settlement ; New Cairo
Construction Year	2015	2017	2010	2012	2011	2014	2010	2021	2022	2013
Area (m^2)	40,000	260,000	1,137	3,000,000	13,000	42,300	38,000	13,000	65,000	42,000
Construction Cost (USD)	84,000,000	5,000,000,000	4,300,000	13,000,000,000	11,000,000	100,000,000	4,640,000	9,400,000	47,000,000	50,000,000
Features of **Efficient energy performance**	•	•	•	•	•		•	•	•	

Innovation Incentives	/Connectivity	Accredited Building	Applying Technology	Efficient architectural design	Efficient facility management	Cost Savings
•		•	•		•	•
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Source: Author; Based on Analysis of SBP

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