The readiness of IoT enabled Smart Buildings in Malaysia

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Abstract. The rapid evolution of the Internet of Things (IoT) has significantly impacted the way of conduct business and influenced current daily lifestyles. Observing this phenomenon, researchers and industry practitioners are increasingly paying attention to the research and development of smart buildings. This research aimed to focus on the readiness of smart buildings in Malaysia and research objectives were set to determine the readiness, potential benefits of implementing smart buildings and the challenges faced in the current state towards adopting smart buildings in Malaysia. Based on the 140 questionnaire survey responses from various construction professionals, descriptive statistics and Kruskal-Wallis test were conducted. This study has contributed to the body of knowledge on understanding on current readiness of Malaysia in the implementation of Smart Building and brought up the main challenges faced towards the adoption of Smart Building. In conclusion, Malaysia has not fully ready to take advantage of the benefits the smart revolution will bring, including greener, safer and more efficient energy use.

1. Introduction

The smart building is very important to the construction industry because it offers a dynamic approach to sustainability of the functioning asset at lower costs and with fewer effort than ever. Besides, the adoption of smart buildings also enhances sustainable development in the country by overcoming environmental issues. However, the construction industry is a conservative industry, so greater efforts are needed to evoke changes in the implementation of smart buildings.

In recent decades, growing numbers of things are being connected to the Internet, thereby enriching the digital world. The Internet of Things (IoT) promotes and improves people's life and work efficiency in many different areas. Thus, the use of IoT devices to make buildings smarter and more efficient is increasing in interest [1]. Cities and urban areas around the world are rapidly evolving as a result of globalisation, emerging smart systems, and the penetration of IoT. Nonetheless, the implementation of smart buildings is still in its infancy for many cities.

According to [2], governments and societies all over the world are increasingly paying attention to the development of smart buildings. In Saudi Arabia, [3] found that the construction industry is gradually integrating smart technology in its buildings. However, Saudi Arabia is still far behind in the use of smart building technologies, only 15% of buildings with appropriate used while 85% are without adequate utilised. In Denmark, [4] observed that the integrated design solutions that different products from different suppliers into one building have become a trend. In China, [5] pointed out that the adoption of smart buildings has widened in the following years.
In Malaysia, considerable attempts are being observed in recent years to integrate smart and sustainable design concepts into future urban planning. [6] has conducted a case study in Malaysia to predict energy consumption in Building Energy Management System (BEMS) for smart buildings by using machine learning. Another case study was also conducted by [7] on awareness of smart energy management in residential buildings in Kajang and Putrajaya, Malaysia. Besides, [8] also conduct a review on the energy efficiency programs and policies in Malaysia. From the previous studies highlighted here, most studies were focused on the building’s smart energy management in Malaysia. It is obviously still lacking of studies on IoT enabled smart buildings in Malaysia, including the awareness and readiness of smart buildings in Malaysia.

Hence, this research will focus on the readiness of smart buildings in Malaysia as well as take an integrated approach to determine the potential benefits of implementing smart buildings and the challenges faced in current state.

2. Internet of Things and Smart Buildings

2.1. Smart buildings

Smart building is a structure utilising the computerised procedure to control the building’s operations automatically involving ventilation, lighting, security, heating, air conditioning, and other systems. Building owners and designers have to consider the developments of environmental systems, climate control, security, access, and fire detection in the design of smart building [9]. The anticipation of smart building is using interdependency among building and business system to achieve the capability of ameliorated operational and energy efficiency as well as overcome facility management challenges, resulting to automated or optimised facility management processes and provide enrichment of data for analysis [10]. Smart building uses microchips, actuators, and sensors so as to administer diverse building operations dependent on particular business functions and services rules as well as gather data which bring about cost-effective and productive environment.

2.2. IoT Technology

The IoT is an information technology that connects physical devices with internet to empower data transmission, acquisition, and processing as well as enable smart identification and management in cloud server [11]. There are various areas in which IoT can improve human life and work in a significant manner, including conveyance, healthcare, automation, facility management, etc. IoT empowers an object to see, tune in, and communicate simultaneously. IoT thus transforms the devices from being intelligent by incorporating its widespread and pervasive communication technologies, computing, embedded devices, and numerous different applications to influence and revolutionise human life [12].

In the era of IoT, a large amount of data and resources had been offered by internet-connected things which provide boundless possibilities for services and applications. The application and services provided by the IoT can be both residential and commercial ranging from automation, e-health, e-marketing, intelligent transportation system, logistic services, etc. Outlook on the future, the internet will comprise a mass of intelligent objects alongside embedded devices and not only being the network of computers. Therefore, the scope and size of the adoption IoT will increase exponentially which provide new opportunities and challenges. Various nations have grown long haul national strategies for the usage of IoT. For example, smart buildings give the capacity to the building occupants to access intelligent equipment remotely from anyplace over the world. The development initiatives framed the establishment of IoT. The main part of these IoT devices is mounted inside buildings, thus give us impetus to the concept of smart buildings. In smart buildings, diverse electronic gadgets and contraptions are interconnected and are communicating with one another. A large amount of data will be generated as a huge quantity of devices are communicating with one another in such a system. Big data analytics and management are expected to play an important role to enhance IoT-enabled smart buildings.
2.3. **IoT enabled Smart Buildings**

The fundamental of a smart building is the ability of standalone technology devices operated with the existing network connection to ensure a good working system of a building [13]. Smart buildings enable to enhance the service for its occupants by incorporating a broad assortment of devices, control systems, sensors, and actuators that are interconnected and jointly function. Besides, smart buildings can be monitored or controlled remotely by integrating a correspondence network within the buildings' components. For instance, all the windows must be closed automatically as an action that is a touch off by the change of temperature before the air conditioner is turned on. Hence, a sensor has to trigger the air conditioner, and afterwards, data ought to be interchanged between the windows and air conditioner. The systems controlling the air conditioner and windows are more likely to be made by various manufacturers based on the technical interoperability viewpoint. This management and automating control of the building requires an integration process [14].

Smart buildings incorporate and account for data from various sources or embedded devices for materials, construction, control, and intelligence as the whole building system. This is to upgrade versatility to meet the worth drivers of the smart building which include comfort and satisfaction, life span, as well as energy and efficiency. Smart buildings enable to provide its occupants with a secure, comfortable and productive environment without compromising on energy and operational performance. For example, some of them incorporate occupancy monitoring systems, smart metering (water, gas, and electricity) and even high-efficiency HVAC systems. Worldwide energy consumption in both residential and commercial buildings has risen consistently and far surpassed the other significant areas such as transportation and industrial. Besides, the demand for comfort levels and building services is increasing together with the building occupancy time due to the population growth, which marks an expanding pattern in the demand for energy. Thus, the energy policy is extremely important as it decides the course that enterprises and industries will take with regard to smart building design, construction, operation, and maintenance. In addition, the HVAC systems consume more energy during building operation when contrasted with other building energy systems. IoT enabled smart buildings to enable the use of data to minimise the energy consumption and optimise operational efficiency.

3. **Research methodology**

In this research, the quantitative approach was utilised to measure the readiness, benefits and challenges of implementing smart buildings in Malaysia. The primary data was collected by distributing questionnaire surveys online. For sampling, a non-probability sampling method which are often appropriate for exploratory research was adopted. Convenience sampling that composed of people who are easy to reach was selected in this study as it was more convenient to collect data and an inexpensive way to gather initial data. After collecting the survey data, statistical analysis is used to analyse the data gathered. SPSS software was utilised to carry out the descriptive statistical analysis and non-parametric test. The results get from the statistical analysis will be interpreted in more generalisable in next section.

The survey area for the research was Klang Valley, Malaysia due to Klang Valley is known as the heartland of Malaysia's commerce and industry and has achieved outstanding construction performance. Moreover, the respondents will be limited to Malaysian construction practitioners such as developers, architects, engineers, quantity surveyor and contractor. They were the right group of respondents who understand the real situation in the construction industry and may have experience in smart building projects. This study was not limited to any specific type of project.

4. **Results and Discussion**

A total of 400 sets of questionnaire survey’s requests were sent out but only 140 responses were received. The respondents’ demographic background was summarised in table 1 below.
Table 1. Respondents demographic (N=140)

| General Information | Categories         | Frequency | Percentage (%) |
|---------------------|--------------------|-----------|----------------|
| Working Experience  | Less than 5 years  | 62        | 44.3           |
|                     | 6 to 10 years      | 35        | 25.0           |
|                     | 11 to 15 years     | 17        | 12.1           |
|                     | 16 to 20 years     | 8         | 5.7            |
|                     | More than 20 years | 18        | 12.9           |
| Profession          | Developer          | 12        | 8.6            |
|                     | Architect          | 22        | 15.7           |
|                     | Engineer           | 25        | 17.9           |
|                     | Quantity Surveyor  | 33        | 23.6           |
|                     | Contractor         | 38        | 27.1           |
|                     | Others             | 10        | 7.1            |

Table 2 indicated results on the readiness in implementing smart buildings in Malaysia. The result on the respondents’ experience in smart building project revealed that more than half of Malaysian construction professionals (n=85, 60.7%) are lack of practical experience as they have not participated in any smart building projects before. The results also inferred that the three most common types of smart building projects in Malaysia were Office buildings (n=26), Residential (n=21) and Commercial Retail (n=19). The other smart building project (n=7) experienced by the respondents were such as research and development (R&D) building, Light Rail Transit (LRT) station, Mass Rapid Transit (MRT) project and their own house.

Results also indicated the smart systems that were commonly used by respondents in the building project were Lighting System (n=46), Energy Management System (n=45), Access Control System (n=44), HVAC Control System (n=43), and Safety and Security System (n=37). Minor respondents had used smart audiovisual systems (n=26) in building project, while the remaining 2.1% of respondents were involved in other systems such as surveillance systems and transporting systems which particularly applied in infrastructure projects. The outcome indicated that there are only partial of construction professionals in Malaysia are familiar with smart buildings system.

Results in Table 2 also inferred most respondents (n=118, 84.3%) were interested in using smart technologies in the buildings. However, less than half of the respondents (n=63, 45%) agreed that Malaysian construction industry is ready for the smart building revolution while 40% (n=56) were unsure whether Malaysian built environment is currently being smart-ready. This revealed that Malaysia is not fully ready to take advantage of the benefits the smart revolution will bring, including greener, safer and more efficient energy use. The knowledge gaps among built environment practitioners in Malaysia need to be bridged as this is one of the major obstacles to the implementation of smart buildings. Stakeholders at all levels may need immediate and effective large-scale capacity building and awareness programs.
Table 2. Results of readiness of Smart Building in Malaysia (N=140)

| Item                                      | Categories          | Frequency | Percentage (%) |
|-------------------------------------------|---------------------|-----------|----------------|
| Experience in Smart Building Projects     | Yes                 | 55        | 39.3           |
|                                            | No                  | 85        | 60.7           |
| Type of project involved for Smart Building | None               | 85        | 60.7           |
|                                            | Office              | 26        | 18.6           |
|                                            | Residential         | 21        | 15.0           |
|                                            | Commercial retail   | 19        | 13.6           |
|                                            | Hotel               | 12        | 8.6            |
|                                            | Education           | 11        | 7.9            |
|                                            | Industrial Warehouse| 9         | 6.4            |
|                                            | Healthcare          | 8         | 5.7            |
|                                            | Others              | 7         | 5.0            |
| Use of Smart Building Systems in Project. | None                | 85        | 60.7           |
|                                            | Lighting System     | 46        | 32.9           |
|                                            | Energy Management   | 45        | 32.1           |
|                                            | Access Control      | 44        | 31.4           |
|                                            | HVAC control system | 43        | 30.7           |
|                                            | Safety and Security System | 37 | 26.4 |
|                                            | Audio visual systems| 26        | 18.6           |
|                                            | Others              | 3         | 2.1            |
| Intention to promote smart technologies in Building Project | Extremely interested | 52        | 37.1           |
|                                            | Somewhat interested | 66        | 47.2           |
|                                            | Not sure            | 16        | 11.4           |
|                                            | Not very interested | 6         | 4.3            |
|                                            | Not at all interested | 0       | 0.0            |
| Readiness of implementing smart buildings in Malaysia | Yes             | 63        | 45.0           |
|                                            | No                  | 21        | 15.0           |
|                                            | Maybe               | 56        | 40.0           |

The Cronbach alpha value of reliability tests on the 10 statements of benefits of smart building and 12 statements on challenges encountered in smart building implementation are 0.911 and 0.878 respectively as shown in table 3 indicated that the constructs are internally consistent and reliable.
Table 3. Cronbach’s Alpha Test Results

| Statements                              | Number of Item | Cronbach’s Alpha Coefficient |
|-----------------------------------------|----------------|------------------------------|
| Benefits of Smart Buildings             | 10             | 0.911                        |
| Challenges encountered in smart building implementation | 12             | 0.878                        |

Table 4 indicated results of the mean agreement and Kruskal-Wallis test of 10 statements on benefits that drive smart building on the construction projects. The findings revealed that 7 out of 10 statements on the benefits of smart buildings have mean agreement of more than 4.0. The seven most perceived benefits of the smart building were *Improving convenience* (mean = 4.24) ranked first, *Enhance occupant’s safety and security* (mean = 4.22) ranked second, *Enhance occupant’s health and comfort* (mean = 4.19) ranked third and *Save energy* (mean = 4.16) ranked forth. These results indicated that the top three important benefits of implementing smart building in construction projects lies in social and behavioural dimensions and the forth benefit is more towards environmental sustainability.

Kruskal-Wallis test was carried out to investigate whether there is a significant difference between one’s profession and his or her opinion on the benefits of smart buildings. The hypotheses for the test were null hypothesis and alternative hypothesis. The null hypothesis (Ho) assumed that there is no significant difference between one’s profession and his or her opinion on the benefits of smart buildings, while the alternative hypothesis (H1) assumed that there is a significant difference between one’s profession and his or her opinion on the benefits of smart buildings.

The results shown a statistically significant difference in the opinion of benefit “*improve convenience*” ($\chi^2 = 16.670$, $p = 0.005$) and “*enhance reputation*” ($\chi^2 = 13.188$, $p = 0.022$) in smart building between different profession. In cities with busy momentum, property buyers are pursuing high quality and improved convenience in living when it comes to buying a property. Therefore, developers and designers will try to embed the design of smart building systems within the property to improve the end-users’ convenience and quality living experience, and concurrently with the aim to enhance the project reputation. Meanwhile, for quantity surveyors and contractors, smart buildings integrate part of design and construction, thereby achieving cost-saving benefits for the project by providing valuable advice about value engineering and cost management shall be their priority. Moreover, contractor’s focus is on the improvement on the efficiency of project management and project schedule rather than concerning on improved convenience of smart building system brought to occupants.

Table 4. Results of Benefits of Smart Buildings.

| Benefits                           | Mean  | Chi-Square $\chi^2$ | Asymp. Sig. |
|------------------------------------|-------|---------------------|-------------|
| Improve convenience                | 4.24  | 16.670              | 0.005*      |
| Enhance occupant’s safety and security | 4.22  | 8.080               | 0.152       |
| Enhance occupant’s health and comfort | 4.19  | 4.384               | 0.496       |
| Save energy                        | 4.16  | 3.032               | 0.695       |
| Increase building value            | 4.08  | 9.570               | 0.088       |
| Increase productivity              | 4.05  | 5.602               | 0.347       |
| Enhance reputation                 | 4.01  | 13.188              | 0.022*      |
| Save water                         | 3.99  | 2.482               | 0.779       |
| Optimise space utilisation         | 3.84  | 3.909               | 0.563       |
| Reduce operating and maintenance costs | 3.65  | 8.718               | 0.121       |
Table 5 summarised the results of mean agreement of 12 statements on challenges of implementing smart buildings in Malaysia. The findings revealed that 4 out of 12 statements are having mean agreement more than 4.0. The four major challenges of implementing smart building were High initial costs (mean=4.52) ranked first, Lack of funding (mean=4.26) ranked second, Lack of a regulatory environment to the adoption of smart buildings (mean=4.11) ranked third and Lack of skilled and specialist workers in smart buildings concepts, devices and solutions (mean=4.02) ranked forth.

| Challenges                                                                 | Mean  |
|---------------------------------------------------------------------------|-------|
| High initial costs                                                       | 4.52  |
| Lack of funding                                                          | 4.26  |
| Lack of a regulatory environment favourable to adopting the concept smart building | 4.11  |
| Lack of skilled and specialist workers in smart buildings concepts, devices and solutions | 4.02  |
| Privacy and data security                                                | 3.95  |
| Limited consumer’s demand                                                | 3.94  |
| Lack of awareness in smart building concepts and technologies            | 3.91  |
| Learning how to operate new systems or training staff                    | 3.88  |
| Reliability of smart building components                                | 3.84  |
| Lack of effective data management                                        | 3.81  |
| Complexity of devices’ connectivity                                      | 3.77  |
| Complexity of prediction task                                            | 3.72  |

The most significant challenge of implementing a smart building in Malaysia mentioned above was high initial costs than a conventional building. Although many people perceive that smart buildings were easy to use and can minimise all operating costs of buildings like energy, air conditioning, and control environment, it is difficult for most individuals to pay the initial cost for this type of construction. Therefore, financial capability and smart buildings will be the main concern for developer [15]. The findings of [16] also showed similar results that high cost of purchasing devices ranked first in the challenges in smart building.

Lack of funding opportunities or failure to access finance on acceptable terms is typically one of the most commonly cited obstacles to investment in smart buildings. This was primarily due to lack of confidence of the potential investors, lack of incentive policies in place, insufficient and instable available funding and lack of attractive financing for owners with low to medium incomes. As public spending decreases, funding opportunities will become limited and the uncertainty over proposed schemes also increases. Similar results in [17] indicated that lack of funding ranked second.

Another major challenge to adoption of smart buildings in Malaysia was the lack of adequate of a regulatory environment favourable to adopting the concept smart building. Smart buildings are a trend that gradually takes shape by the day, but it must be ensured that not only will smart buildings happen, but they will happen in the right way. As perceived by [18], a range of standards and regulations were needed to help the smart building meet its potential as these regulations will help address issues at various levels which creating an environment that promotes public confidence and ensures stability, transparency, competition, investment, innovation, and growth in the city.

Among the challenges of implementing smart buildings in Malaysia, the complexity of prediction task was ranked at the last with the mean of 3.72. In general, occupant’s behaviors are not likely to remain constant, but to change over time. Besides, they may have unique patterns that overlap in time or space and may also have patterns that only occur when combinations of occupants occupy the space simultaneously.
There are two other challenges of implementing smart buildings in Malaysia which were highlighted by six of the respondents during the questionnaire survey: 1) Lack of government incentives to implement energy-saving and 2) smart building initiative and resistance to change from traditional buildings. The adoption of government incentives can promote the implementation of smart buildings, but this depends on government policy. At the moment, there are lack of incentive policies in place and therefore the cost for such adoption and investment falls on service users [19], including Malaysia. Apart from that, the findings revealed that the existing culture and environment in Malaysia as well as the mindset of building owners and users mostly resist to change from traditional buildings. The willingness of local citizens to accept new technology is low due to concerns on the significant price increase and unproven technologies in Malaysia.

In order to overcome these major challenges, the government should come out with incentives to support building developers to incorporate more IoT enabled smart applications in the building design, which end up being sustainable buildings in our cities. Moreover, there is a strong need for government to come up with enforcement policies to incorporating IoT enabled smart applications into urban planning and the enforcement action should start right away. The building developers should also start to create awareness and marketing on the benefits of IoT enabled the smart home system to the housing buyers. There is also a need for Malaysian higher education to educate more talents and create more researchers who are to come out with Malaysian own smart home application, which end up to be more cost-effective in long run. These shall involve providing more research grants on the researching on IoT enabled smart building application. Finally, there is a need to educate Malaysian citizens on the benefits perceived by the IoT enabled smart building through education institutions. These overcoming strategies which involved government, developers and researchers should be concurrently implemented and no doubt Malaysia can be a step closer towards achieving sustainable cities.

5. Conclusion and Recommendation
It can be concluded that Malaysia has not fully ready to take advantage of the benefits the smart building offer. The Malaysian construction professionals might know the concept and how powerful smart buildings are, but they are lacking opportunity to realise it. This study has contributed to the body of knowledge on understanding on current readiness of Malaysia in the implementation of Smart Building and brought up the main challenges faced towards the adoption of Smart Building in Malaysia. Furthermore, this research has also provided great advantages to identify the area where more efforts are needed and, therefore, the direction of future research. The recommendations for future research are to explore further smart buildings readiness from different aspects such as technology, people, and management and determine the strategies to overcome the challenges of implementing smart buildings in Malaysia.

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