Challenges to the Adoption of Smart Building Systems: A Property Management Perspective

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ABSTRACT

The implementation of smart building systems has become a focus on across the globe to achieve improved energy conservation and sustainability in the building. Yet the pace of implementation of smart building systems in Malaysia is slow due to certain challenges. This research aims to recognize the key challenges to adopt smart building systems by property management professionals. Primary data were obtained through a questionnaire survey administered to 100 respondents who were the property managers in Johor Bahru. Data were processed by the SPSS software and ranked with Relative Importance Index (RII) method to determine the challenges with higher impacts. Results indicated that the highest rank of challenge were high cost of smart building system installation (RII = 0.942) and past habits and preferences (RII = 0.930). On the other hand, the challenges of lack of legislation and policy frameworks (RII = 0.764) and the privacy and security concerns (RII = 0.774) were among the least significant problems raised. In conclusion, this study emphasizes that these challenges must be addressed comprehensively to ensure the successful implementation of smart building systems in Malaysia. The implications of the study suggest that policymakers, industry practitioners, researchers, and end users should collaborate to develop cost-effective solutions, enhance technical knowledge, improve IoT infrastructure, and establish clear policy and regulatory frameworks. Such efforts are important to increase the penetration of smart-building systems and address the national agenda for sustainability.

Keywords: Smart Building Systems, Challenges, Property Management, Sustainability

INTRODUCTION

The Fourth Industrial Revolution (IR 4.0) has triggered significant changes in various aspects of society, including the economic sector, technology developments and lifestyle behaviour. The rapid evolution of technology worldwide has become a benchmark for a nation's development. For Malaysia, it is an opportunity to keep pace with the rest of the world in terms of innovation. The development of real estate and property industry in Malaysia should be more prepared to face the challenges for an improved national development and able to compete with developed countries using advanced technology such as the Internet of Things (IoT), especially in the application of smart systems in new building or to blend the management of smart system into the existing buildings.

Sabri and Yahya (2020) suggested that the use of smart building systems can potentially improve sustainable development in a country as well as for proving that the country is viable. New technologies must be installed either to improve existing procedures or to develop new applications. In addition, smart building systems can be synchronized with IoT applications where data and information are gathered into a single platform, enabling more effective management at multiple levels within a building (Minoli et al., 2017; Kiu et al., 2021). However, in the developed countries where smart building systems have become a common practice, only a few buildings have adopted such a technology in Malaysia. Emerging markets in Asia, for example, Malaysia, Singapore, Thailand, and Indonesia, tend to have low utilization of smart buildings in the face of technology adoption and strategic opportunities of real estate development (Yang & Lee, 2018).

The construction and real estate industry is a naturally conservative industry, and it takes longer for it to accept change in adopting smart building systems. This growth is illustrated by recent developments and trends in smart building research that go beyond the traditional centralized building automation system. Traditional building management system which fails to leverage rich user data are facing a great challenge. With new technologies being adopted, more data about buildings and users will be collected. Consequently, knowledge and skills in the application of smart technology are important for Malaysia to move forward in the IR 4.0 era. Furthermore, the penetration of smart system technologies in the construction sector, via smart buildings, smart homes and smart cities, is still quite low in Malaysia, hovering around 25% (Lueth, 2015). The smart building system application is yet to grow due to the slow market uptake in land and property development. Also, the recent use of smart system technology in the country has resulted in most developers, owners and building managers sceptical in using smart building system due to risk of adopting smart building system (Mohamad and Omar 2021).

In this sense, an efficient management of smart building systems can reduce the energy necessary to the same and therefore contribute to a more sustainable energy economy. Prior research has highlighted that monitoring of energy use and a strong focus on energy reduction have become important issues, particularly due to increasing concerns over climate change and CO_2 reduction targets (Pérez-Lombard et al., 2008; Ascione et al., 2017). Shah, Ma, and Gulliver (2010) emphasize that sustainable intelligent buildings should be evaluated using key performance indicators encompassing both energy efficiency and occupant comfort, among other criteria.

Smart building systems indirectly affect every operation in the building by allowing for optimization of systems inside the space by facility operators, enabling higher tenant satisfaction, higher lease rates and less energy waste. The commercial and residential buildings that have so long been popular investments with property pros are slowly integrating smart building systems for use. Pérez-Lombard et al. (2008) argued that buildings are one of the largest use consumers of energy in the world, and they account for between 20% and 40% of energy use. Owners and investors have a growing awareness of how technological advancements of today can enhance future building returns, given how functions and features have evolved over time to accommodate both old and new buildings. While these developments may give rise to breakthroughs, they also involve certain challenges with respect to user engagement. The importance of building management and end users has thus been more focused on as a method to increase energy-saving behaviour (Paone & Bacher, 2018). Although there is potential to further engage, both building managers and end-users in smart buildings, there are also challenges in terms of information overload, surveillance and privacy (Callaghan et al., 2009).

It is clear that along with the advantages of smart building systems within building space, there are also many difficulties in taking advantage of this technology trend. Since smart building systems continue to become more sophisticated and technologically advanced for both the building management and for end-users, it is important that research in the domain of smart building also keeps pace with innovation. Notwithstanding the growing opportunities and advances in this area, there are still several challenges which restrict the deployment and adaptation of such systems. Therefore, such studies to investigate the challenges of the smart building system are necessary, especially for those practitioners who contribute in the property management. Then it raises the question: What challenges prevent the smart building system from being accepted?

Given the background above, the goals of this study are to understand the challenges of adopting smart building technologies and to investigate the critical challenges of implementing smart building systems. The results of this study make a significant contribution to filling the gap of existing knowledge on the barriers against smart building adoption and offer useful guidance in helping the policy makers and practitioners play a major part in reducing these challenges to facilitate the design and application of smart building systems.

LITERATURE REVIEW

Numerous aspects related to the challenges in adopting smart building systems have been investigated by researchers and practitioners in the field of smart technologies. Previous studies have demonstrated that critical barriers exist among professionals involved in building management.

High Cost of Smart Building System Installation

Smart building technology has significant startup costs. The cost of installing smart systems is a significant part of overall expenditure in smart building infrastructures. These costly investments can make building owners and developers hesitant to adopt. Previous studies have also reported that the cost of implementing smart technologies (e.g., smart homes) is high (Hong, Nam, & Kim, 2020). Ghansah et al. (2021) also observed that the initial investment cost of smart buildings is greater than that of standard buildings, especially in materials and devices. Integration costs can also become higher, as smart systems may be increasingly complicated to be integrated in existing conventional building stock (Vargas et al., 2022; Kiu et al., 2021). The retrofit of smart systems into existing buildings is extremely difficult and expensive, since older buildings simply do not have the infrastructure to support the new smart technologies, which require quite a bit of investment in additional sensors, as well as swapping out HVAC and lighting control. This leads to a significant increase in upfront costs for the device, its installation, maintenance, repair, and energy use, thereby reducing the device's investment potential.

Increasing Complexity of Building Functions

The integration of smart systems may be hindered by compatibility issues, conflicting protocols, and the requirement for centralized management (Aliero & Raji, 2022). Jia et al. (2018) argued that the integration of multiple functions requires extensive planning to address the unprecedented levels of complexity and interdependencies across systems. Smart buildings are those which can create indoor conditions satisfying the preferences, positions, and activities of inhabitants. The benefits of such system solutions are indeed numerous; however, their full integration may not be easy, given considerations related to compatibility, conflicting protocols, and the need for centralized control (Vargas et al., 2022; Tan & Taeihagh, 2020). Moreover, the growing sophistication of building operations complicates both the issue of scaling up and staying nimble. Systems and components should be smoothly added or changed without disturbing existing operations. Scalability and flexibility are key to integration of new technologies and achieve user requirements over time. Moreover, real-time feedback and the active feedback can contribute to improve the experiences of users and the effectiveness of the use of smart building technologies.

Resistance to Adopt New Architecture Technologies

According to Jia et al. (2018), many smart building technology architectures demand a learning curve that is too steep for building owners, operators, and occupants. The complexity of these technologies and the level of skills and knowledge required can create resistance to change (Affonso et al., 2024). Some researchers suggest that the design of smart building should be from architectural-design and needs the cooperation among the owner of the project, the architect, the system-design and the end-user. Mixing various systems and technology could cause compatibility and interoperability problems. Consequently, building owners and operators may be resistant to invest in new technology architectures if they anticipate difficulties in integrating with existing systems or achieving seamless communication across different devices and platforms (Vargas et al., 2022; Kiu et al., 2021). Thus, smart buildings and devices need to be reliable as well in all aspects, offering an attractive physical design.

Privacy and Security Concerns

Smart building systems rely heavily on the collection and analysis of large volumes of data, some of which is sensitive personal data (e.g., patterns of occupant's presence, behaviour or preferences) (Zhan & Chong, 2021; Sicari et al., 2015). People worry about privacy and cyber security, especially as smart devices and wireless networks capture and transmit more data, which can make adopting smart buildings difficult. Study highlights that smart building environments can pose significant privacy risks—ranging from data misuse and unauthorized access to pervasive tracking—often exacerbated by occupants' lack of awareness about what and how their data is being collected (Bakar et al., 2024). In a similar vein, Aliero et al. (2022) focused on the fact that, if on the one hand IoT-enabled smart building technologies improve the efficiency, the comfort, and the convenience, on the other hand they amplify the personal data risk. Alaba et al. (2017) and Roman et al. (2013)

pointed out that the lack of standardized security protocols amplifies privacy and security issues in smart building systems.

Inadequate IoT Infrastructure

Al-Fuqaha et al. (2015) also claimed that reliable IoT infrastructure is necessary for a seamless connection as well as scalability in smart buildings to achieve the full network coverage. This includes some wireless networks (Wi-Fi, Bluetooth) and enough network capacity and quality (bandwidth and QoS) for data to be transmitted. An efficient and scalable infrastructure is therefore required to deal with the increasing complexity of big data produced by the IoT and to enable smooth operation of smart building systems (Carcary et al., 2018). Zanella et al. (2014) identified lack of interoperability standards and integration as major impediments. Similarly, Minoli et al. (2017) emphasized that improved IoT infrastructure must include scalable data storage, data processing methodologies, and continuous analytical frameworks to handle large volumes of data and extract actionable information.

Lack of IT Knowledge and Skills

Lack of technical skills is also an obstruction to IoT implementation in the enterprise. The absence of IT experience constrains the system potential performance and the ability of comprehending and exploiting these technologies (high-performance management and underutilization of the potential smart building), that characterizes a significant percentage of building systems (Schall et al., 2019). According to Abazi (2016), the knowledge gaps within organizations include top management’s lack of knowledge of IoT, top management's inability in managing the IoT, employees' lack of skills, and lack of specialists such as data analysts which reinforce the skill gap. The rapid evolution of smart building technologies has outpaced the availability of comprehensive training and educational programs for building professionals. Moreover, construction professionals require a strong understanding of IT infrastructure components and protocols to effectively integrate and manage these complex systems (Al-Shabatat, 2020). Consequently, the successful implementation of IoT requires hiring experts with special knowledge and promoting digital competences among the staff to deploy and exploit IoT in buildings (Kiel et al., 2019).

Past Habits and Preferences

Vargas et al. (2022) noted that building owners, managers, and maintenance staff are often reluctant to alter their habits, as they are already accustomed to conventional building management practices through years of experience. This preference reduces their incentive to use new technologies, perceiving more trust on old-fashioned systems and the impossibility of increasing interest in advanced technologies (Augello et al., 2019). Significant investment is necessary to implement new techniques, devices, and procedures into building management of building, operation and control via intelligent systems (Vass et al., 2021). Tan and Taeihagh (2020) also stressed that new technology adoption is susceptible to organizational culture. Resistance to new technologies can stem from a lack of organizational support, scepticism, and fears related to job vulnerability or displacement (Cieslak & Valor, 2024).

Lack of Legislation and Policy Frameworks

The absence of specific legislation and policies has resulted in weak standards, creating challenges in data sharing, data protection, and ownership clarity (Birkel, 2019). Authorities need to identify mechanisms to drive progress in emerging technologies such as the Internet of Things (IoT) and Artificial Intelligence (AI), and to systematically integrate these technologies into smart buildings, whether in the construction of new buildings or the retrofitting of existing ones, to enhance economic competitiveness (Yaqub & Alsabban, 2023). Lack of guideline makes it difficult for players to understand what the legal requirement, compliance and what is expected from them to the usage of these technologies. Policy measures such as building codes, regulations, and incentives can be important catalysts to promote the implementation of smart building systems aligned with sustainability objectives (Kiu et al., 2021; Tan & Taeihagh, 2020). Nevertheless, under the absence of relevant laws and regulations, issues around safeguarding personal information, data privacy and security loopholes remain.

RESEARCH METHODOLOGY

The aim of this study was identifying the critical challenges in the adoption of the smart building systems. Key challenges for the successful adoption of smart building systems were measured in this research by primary data through a questionnaire survey given to the property manager to capture perspectives of the parties involved in the processes. The sampling method employed in this study was purposive sampling. This approach enables the selection of respondents most likely to provide relevant and accurate information, thereby enhancing the validity of the study and ensuring a more precise understanding of the challenges associated with smart building adoption. Hence the study sample was confined to the property manager in Johor Bahru. A figure of 195 professionals was ascertained to be the sample size. Based on Taro Yamane's formula, at least 99.72 respondents were required to complete the questionnaire. Considering this, the researcher decided to collect data from 100 respondents. The questionnaires were distributed both face-to-face and via Google Forms to those unable to participate in person.

Data Analysis

A quantitative approach was applied to determine the results using a scientific methodology. Data collected from the survey on critical challenges in implementing smart building systems were compiled and analysed using the Statistical Package for the Social Sciences (SPSS). Additionally, the Relative Importance Index (RII) method was employed to rank the challenges based on the responses obtained, allowing for more detailed and precise questionnaire analysis.

The analysis in this study was conducted based on the frequency of data obtained for each stated challenge, with the ranking values arranged from highest to lowest. A higher RII value indicates that the challenge has a stronger influence compared to those with lower index values.

FINDINGS AND DISCUSSION

The Relative Importance Index (RII) analysis was employed to determine the ranking of each challenge identified in the adoption of smart building systems. Table 4.1 below presents the results of the analysis.

Table 4.1: RII Analysis Results for Critical Challenges in the Adoption of Smart Building Systems

Challenge	**RII**	**Rank**
High Cost of Smart Building System Installation	0.942	1
Past Habits and Preferences	0.930	2
Resistance to Adopt New Architecture Technologies	0.858	3
Lack of IT Knowledge and Skills	0.858	4
Inadequate IoT Infrastructure	0.828	5
Increasing Complexity of Building Functions	0.810	6
Lack of Legislation and Policy Frameworks	0.774	7
Privacy and Security Concerns	0.764	8

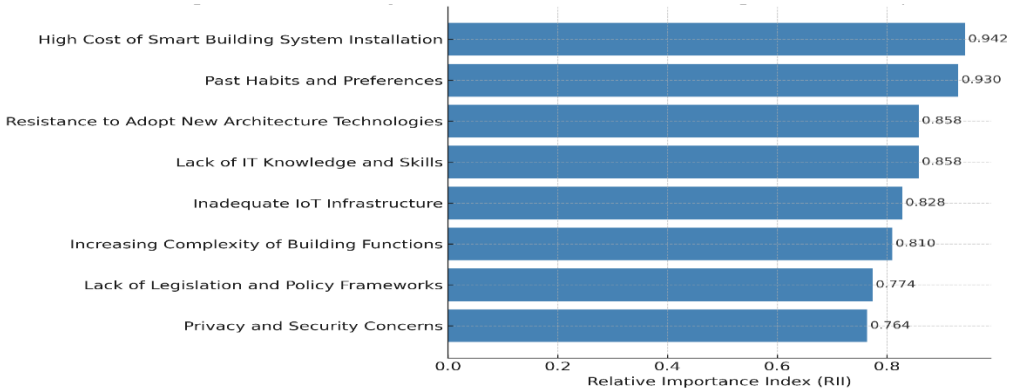

Figure 4.1: Relative Importance Index (RII) Ranking of Critical Challenges in Smart Building Adoption

Figure 4.1 illustrates the rank of the challenges in implementing smart building systems, as identified by the respondents. These eight critical challenges in the adoption of smart building systems were identified as influencing respondents' perspectives in building operations management. The results indicate that these challenges are significant in providing knowledge for both existing smart buildings and those planning to adopt such systems. The analysis further demonstrates that the higher the ranking of a challenge, the greater its perceived importance.

The most critical challenge (RII = 0.942) was the high cost of smart building system installation. This in aligned with earlier research which indicated cost as major obstacle to smart building implementation (Tan & Taeihagh, 2020). Smart buildings cost more than traditional buildings, especially in the materials and equipment. The high costs of purchase and installation of the device as well the maintenance and repair eat heavily into the initial investment of capital.

The second ranked challenge (RII = 0.930) was the habits and preferences of the property managers that caused the unwillingness to shift from traditional approaches to smart building systems in operating activities. Of the 100 respondents, 73 overwhelmingly supported this challenge. Such finding is consistent with other research, which emphasize that the implementation of smart building systems involves heavy effort to make new methods, tools, and way of doing working management, and operations control (Vass et al., 2021). The past habits and preferences of property managers may hinder their adoption of new methods.

Both the lack of IT knowledge and skills and the resistance to adopt new architecture technologies showed equal rank with RII = 0.858. Many property managers were found to be comfortable with conventional practices and showed little interest in learning advanced modern technologies. This is consistent with the findings of Affonso et al. (2024) & Ricardo Vargas (2023) argued for the complexity of the technology which necessitates special skills and know-how as contributing to an unwillingness to change.

Inadequate IoT infrastructure was the fifth challenge which its RII was 0.828. Disruptions in the networks or in infrastructures can affect or stop the operation of smart building systems and its management and maintenance which become more and more difficult because of an increasing dependence on the IoT. This is in aligned with the Carcary et al. (2018), where they pointed out, that efficient and scale-able infrastructure plays an important role and is necessary for managing the complexity of collection and processing of IoT data and to operate the system smoothly.

The challenge of increasing complexity of building functions was ranked sixth, with RII of 0.810. Operating and maintaining smart systems involves specialized trainings to have an understanding of technology at a significantly deeper level. Minoli et al. (2017) concluded that integration may also be difficult, as protocols and management approaches are often incompatible and require centralized coordination.

Lastly, the two least challenging issues were the lack of legislation and policy frameworks (RII = 0.774) and privacy and security concerns (RII = 0.764). This finding is consistent with Alaba et al. (2017) and Roman et al. (2013), who identified a lack of standardized security policies and procedures as the cause of increased security and privacy risks associated with smart building systems. The lower rankings may be attributed to

Malaysia's current stage of smart building adoption. Since the implementation of smart building systems remains limited and evolving, many property managers may not yet have encountered significant policy or security challenges in practice. Consequently, these issues are perceived as less immediate when compared to financial, technical, and operational barriers that directly influence day-to-day decision-making and resource allocation.

CONCLUSION

The findings of this study show that the challenges related to the adoption of smart building systems should be looked into and addressed. These findings are of special importance for property managers as they provide valuable insights into the key challenges to implement smart building systems. By recognizing and addressing these challenges, professionals can work towards buildings that are more environmentally sensitive, more energy-efficient, more health-fulfilling for people and more effective in providing for the overall needs of building occupants.

The findings of this analysis also could sensitize policymakers and property managers to potentially bypass these challenges, such as by providing financial incentives, delivering training, strengthening infrastructure, and by developing transparent rules and policies. These needs will only be solved by a concerted combination of action by industry players, government, academia, and end users, working together to develop affordable solutions, raise technical capacity, engage users, build infrastructure, and enact conducive regulations.

In summary, this study offers an insight on the necessity to acknowledge and address the challenges that prevent smart building application adoption. Facility management and property management professionals can help move the needle with smart building systems or technologies to elevate the quality, energy efficiency, sustainability and overall performance of the build environment.

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