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Green Strategies During Lower of Occupancy: The Best Practices of Facilities Management for Energy Optimization in Commercial Office Buildings

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ABSTRACT

The increasing global emphasis on sustainability and environmental responsibility has influenced the field of Facilities Management (FM). Emphasis on energy consumption during peak hours has been widely studied by many researchers. However, FM also plays an important role in optimizing the use of energy during lower occupancy periods energy. This paper explores the implementation of green strategies within FM practices to increase and optimize energy use during lower of occupancy during working hours. This paper investigates the current green strategies for energy efficiency in commercial office buildings that can be conducted during lower of occupancy. Interviews and observation are conducted for three selected buildings to collect data and analyze which practices are suitable. This research uses qualitative methods by interviewing facility managers and BO Chargeman to gather detailed information and observations to gain more understanding of the situation of research by assembling the current practices of green strategies. This result will help the data collection to be more effective in gathering varied recommendations of the best practices of green strategies on energy efficiency focusing on lower occupancy periods. At the end of this study, it will figure out the best practices of green strategies that can be implemented in building energy efficiency purposes focusing lower occupancy periods. The finding shows adaptation to technology and training to provide awareness for occupants is the best practice to empower towards facility manager in Malaysia for energy optimization approaches.

1. Introduction

In the face of global environmental challenges and the imperative to reduce carbon emissions, the efficient and sustainable operation of commercial office buildings has gained paramount importance. The construction and operation of office buildings use a lot of energy, which has a negative impact on the environment as well as the comfort and health of its occupants [1]. This work explores critical strategies and practices that facilities management (FM) professionals can employ to enhance energy optimization during lower of occupancy, contributing to the overall sustainability of commercial office buildings. Commercial buildings are significant contributors to energy

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consumption and greenhouse gas emissions, and thus, the reduction of their environmental footprint is crucial [1].

Commercial buildings are among the most prominent contributors to energy consumption and carbon emissions worldwide [2]. Their operation and maintenance consume vast amounts of resources and energy, posing a substantial environmental challenge. The imperative to address this challenge by minimizing energy consumption and environmental impact is clear. However, the methodical execution of such sustainable operations requires a profound understanding of the dynamic relationship between FM practices and energy optimization especially during lower occupancy periods. Although other studies have shown that facilities managers are not included in the design process, there hasn't been much discussion on how important it is for them to be involved. Considering this, the study advances our knowledge of the significance of their interest in the design process. Design process is a process that can apply green building elements [2]. This research delves into the role of FM in achieving energy optimization within commercial buildings and emphasizes the importance of targeting lower occupancy periods as a prime opportunity in sustainability.

2. Literature review

2.1 Facilities Management (FM) Definition and Feature

According to [3], the job of practice that covers all aspects including asset, space, environmental control, safety and health and support of services is FM (Figure 1). However, [4] mentioned that FM is one of the disciplines that creates a surrounding or environment that is conductive to carrying out the organization primary operations, captivating an combined interpretation of the services infrastructure and utilize this to deliver satisfaction of customer and value for money by provision for improvement of the main business. Another research defined FM carrying together information from design and information from organization in the context of development in everyday utilize. As continues, observing on the apparent changes among current day facilities managers and designers [3]. FM also defined as the addition of people and business procedures of an organization with its bodily workstation affecting the triple lowest line of economy, environment and equity [5]. However, [4] stated that facilities usually be managed as system of integrated. FM as the discipline of organizing the bodily workplace or workstation with the individuals and work of the group.

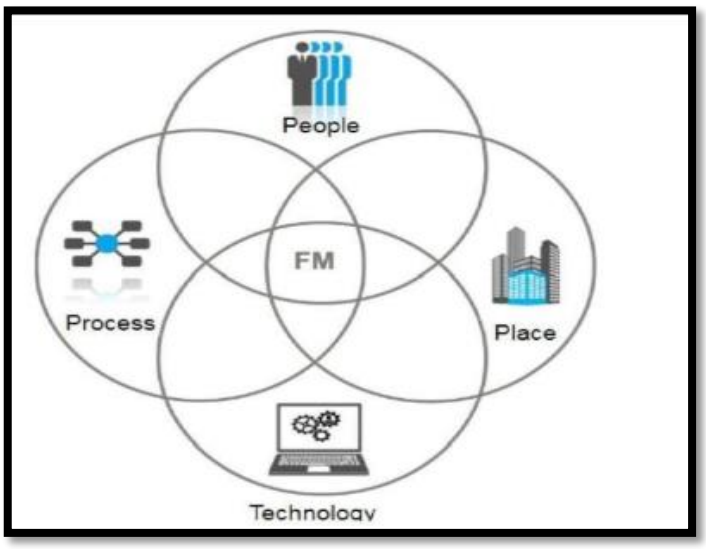

Fig. 1. The International Facility Management Association

2.2 Facilities Management (FM) in Malaysia

FM need to enhance the provision of facilities management to make sure the structure is in good condition such as clean, safe and filled with safety environment. For instance, which has been done in UITM, the FM Division is one of the major divisions, who is responsible for all maintenance in the structure and the area around campus. There are four departments in FM Division, which is Public Unit, the Assembly Unit (UAKM), Unit of Mechanical and Electrical and Telecommunication Unit (UMET) [6]. According to [7], they stated that this type of structure basically would have their own organization or management team to monitor and supervise the building condition. This management team normally handle by maintenance or facility managers. According to [8], the government need to take a critical responsibility into adaptation of FM in Malaysia because only government authorities like the Public Works Department (PWD), presently adopting and implement FM. However, [9] being trusted to investigate growth of the construction industry has engaged the preliminary step to address the problem in FM with teamwork of the industry experts and players in the market. Research done by [10], FM in Malaysia has remained established for more than 10 years and had handled a lot of issues regarding to the discipline and practice. This is cause by a lot of misunderstandings and lack of visions in understanding the perception of actual FM.

2.3 Green Facilities Management (FM) on Energy Optimization

The facility manager would be individual that most likely and best positioned to supervise the organization's green strategy or Corporate Social Responsibility (CSR) strategy [5] . According to [11], energy optimization techniques, for instance consume of renewable energy resources, efficient of heating and ventilation & air-conditioning (HVAC) systems, control indoor air quality and optimization of non-natural and daylight illumination. However, [12] mentioned that by installing CFL and LED (light-emitting diode) lamps, proved to reduce in lighting demands. Next, [13] mentioned that employers need to encourage energy preservation among their employee. However, [14] emphasis that FM team need to be educated and connected about the detail that long-term financial and chronological investments in energy saving technique.

2.4 Factor Influencing Green Practices Adoption

Many theories have been made by past studies about factors in influencing green building practices. This study was done for the sake of user comfort without having a negative impact on the ecosystem and environment. Because buildings are among the contributors to electricity consumption in terms of lighting, HVAC, all parties need to play a role to optimize and reduce the use of electricity in terms of energy efficiency. According to [15], about the topic certification of green building, the main goal of adopting green buildings has problem, inconsistent and the major part is ambiguous. Important of organization decision or who ever created by significant decision makers are the major factors influencing to the adoption of green building. Green certification implementation is eased by organizational main functions that driving to sustainable norms. Certification of building is to assess and identify the development that fulfil several sustainability requirements and standards. According to [15], the findings proved that the respondents debated the issues that encourage the use of green building principle, consisting reduction of operating costs, enhancing tenant health and comfort, enhancing asset values and producing a bigger return on investment, every factor that impact green building implementation is a good return an advantage after using it. Study done by [16] showed, several factors are influencing the green certification

adoption for building, observation of the development green certification advantages, where it is essential to encourage people to accept the building by representing its benefits and commitment of government towards green building project, where they can execute certain regulations that encourage energy efficiency and conservation with convincing the public to implement practices of green building.

3. Methodology

To accomplish this research objective was to recommend the best green strategies of FM on energy optimization focusing on lower of occupancy periods for commercial office buildings. This paper involved in a face-to-face semi-structured interviews to combine deeply all information by interviewing the facility manager and BO Chargeman of these 3 buildings. Participants that were targeted were dealt with operational activities, which is the position of managerial in the FM and maintenance department. Table 1 lists the research steps involved in the study.

Table 1
Sampling Technique

Research question	Research objectives	Research Methods	Research strategies/methods
What is the best practice of green strategies of FM on energy optimization on lower of occupancy periods in commercial office building?	To recommend the best green strategies of FM on energy optimization on lower of occupancy periods in commercial office building.	Findings from interview with six respondents	Thematic analysis

Note: A non-structured interview method was employed

3.1 Interview

Two positions of FM practitioners from three different selected buildings in Pulau Pinang for data collection through interviews. The positions designated as respondents in Table 2 for this research include Facility Manager and BO Chargeman. Each respondent has prepared data according to their experience in the respective sectors they are obligated to. Participants that were targeted were dealt with operational activities, which is the position of managerial in the FM and maintenance department. In this study, FM practitioner is referred to specific positions which are facility managers and BO Chargeman. The respondents also consisted with experience of more than 5 years in the field and contributed their services in their building. These respondents have been selected due to the focus of the research which is energy optimization, and those respondents are suitable to fill the question requirement.

Table 2
Detail of respondents involved in interview

Interviewee	Position	Work experience
Respondent A1	Facility Manager	20 Years
Respondent A2	Facility Manager	19 Years
Respondent A3	Facility Manager	24 Years
Respondent B1	BO Chargeman	8 Years
Respondent B2	BO Chargeman	11 Years
Respondent B3	BO Chargeman	14 Years

3.1.1 Findings

By determining the practice of green strategies of FM on energy optimization on lower of occupancy periods in commercial office buildings, the best green strategies can be recommended. Qualitative data has been used for this objective research where interviews have been conducted to obtain data about the recommendation of the best practices of green strategy.

The implementation of energy optimization strategies in commercial office buildings, especially during lower occupancy, is vital for reducing energy use, operational costs and environmental impact. This study has explored various approaches, including the implementation of advanced technologies such as Building Automation Systems (BAS), LED lighting systems and other technologies. The findings show that technology and occupant engagement can help significantly enhance energy efficiency and lead to sustainable building performance.

4. Results and Discussion

4.1 The Practice of Green Strategies of Facilities Management (FM) on Energy Optimization During Lower of Occupancy in Commercial Office Building

4.1.1 Equipment and appliances used

The interviews highlight HVAC systems as the foremost energy consumer in building operations, particularly through the extensive use of chillers and associated components. This statement supported by [17], office building, for instance the HVAC system, office appliances and elevator systems, frequently utilized the highest electrical energy during maintenance and operation phase. Lighting systems also stand out as significant contributors to energy consumption due to their essential role in maintaining workspace illumination. Research done by [18] mentioned, lighting system consume 34 % of energy in his study on three Malaysian government office buildings. While elevators were noted for their energy usage, they were less frequently emphasized compared to HVAC and lighting. These findings underscore the importance of focusing on HVAC and lighting efficiency measures to potentially reduce overall energy consumption and enhance sustainability in building management strategies.

4.1.2 Current practice

This analysis compares the energy management practices between Company A, B and C based on the insights provided by respondents. Company A employs a systematic approach with visible stickers on electrical appliances to promote energy awareness and efficiency, alongside practices like reducing chiller operating times and ensuring timely maintenance. In contrast, Company B focuses on practical measures such as installing timers for lighting in common areas to automatically reduce energy consumption after working hours. Respondents from both companies emphasize operational adjustments to optimize energy use, such as minimizing AHU compressor operations and rotating chillers. These practices reflect a proactive stance towards energy conservation and efficiency, integrating awareness campaigns and technological solutions tailored to their respective building management strategies.

4.1.3 Technology/strategy

This provides insights into varied approaches and technologies employed to optimize energy use in buildings, as highlighted by the respondents. Respondents A1 and B3 emphasize the use of signage

and stickers on electrical appliances to promote energy-saving awareness among building occupants. Respondent A1 also discusses operational strategies like reducing chiller operation times to conserve energy during non-peak hours. In contrast, Respondent B1 focuses on technical strategies such as Planned Preventive Maintenance (PM) to ensure system efficiency and reduce breakdowns. Respondent B2 introduces the use of timer systems for lighting in common areas, aimed at reducing unnecessary energy consumption outside of operational hours. These diverse approaches illustrate a comprehensive approach to energy management, combining awareness campaigns, operational adjustments and technological solutions tailored to enhance energy efficiency and sustainability in building operations.

4.1.4 Measurement to measure

After implementing strategies to optimize electricity usage in the building, it is crucial to evaluate their effectiveness through various metrics as suggested by the respondents. Respondent A1 emphasizes financial control and reduced maintenance costs as indicators of success, aligning with operational efficiencies gained from green practices. Respondent A2 focuses on direct reductions in electricity bills as a measure of the strategy's impact, highlighting tangible financial savings. Respondent A3 underscores the importance of human behavior in achieving optimal energy use, noting that tenant awareness and compliance play significant roles. Respondents B1 and B2 emphasize the adoption of energy-efficient technologies such as LED lighting and inverters, which contribute to both cost savings and enhanced durability. Technology such as BCS also offers energy-efficient technology approach where BCS offers a wealth of information on building performance and is essential for controlling energy use. In the case study, BCS efficiently monitors the building's internal characteristics and automation system while also providing good control over energy use. Respondent B3 suggests monitoring daily electricity consumption such as Energy Management System (EMS) to assess the effectiveness of implemented green strategies. Research done by [17], to obtain and display the records for the building's everyday operations, a necessary technology that enhances energy efficient is the Energy Monitoring technology (EMT) might be taken into consideration. These insights collectively illustrate a holistic approach to evaluating the success of energy optimization efforts, combining financial savings, technological upgrades, behavioral changes and systematic monitoring to achieve sustainable and efficient building operations.

4.1.5 Challenge

Implementing strategies to optimize energy use in buildings faces several common challenges, as highlighted by the responses of the six respondents. These challenges include reluctance among occupants to adhere to energy-saving guidelines despite efforts to promote awareness and identify efficient appliances, as noted by Respondent A1. In a study by [19], obtained that occupancy and behavioural patterns are to attribute for the differences between the expected and actual energy consumption of buildings. Respondent A2 points out tenant complaints about comfort levels and temperature settings, which can undermine efforts to maintain optimal energy efficiency. Respondent A3 underscores the difficulty in aligning occupants' behaviours with energy-saving practices, exacerbated by insufficient promotion of green strategies [20], proving that building occupants are among the causes that influence excessive energy consumption Respondent B1 elaborates on tenant dissatisfaction with temperature control, reflecting differing preferences that complicate energy management. Respondent B2 notes varying levels of commitment to energy-saving behaviours among occupants, further complicating consistent implementation. Respondent

B3 emphasizes the ongoing challenge of raising awareness and fostering consistent energy-saving habits among building users. These insights collectively illustrate the multifaceted nature of challenges faced by building management in achieving effective energy optimization, necessitating comprehensive strategies that address behavioural, comfort-related and communication barriers.

4.2 Recommend the Best Green Strategies of Facilities Management (FM) on Energy Optimization on Off-Peak Working Hour in Commercial Office Building

4.2.1 Area to optimized energy

This study analyzed the potential for optimizing energy use within building infrastructure during periods of lower occupancy, based on insights gathered from structured interviews with building management professionals. Table 3 identifies several key areas, including meeting rooms, prayer halls, cafeterias, offices, pantries, toilets and parking areas, where fluctuating occupancy patterns present opportunities for efficiency improvements. Respondents emphasized the feasibility of implementing strategies such as adjusting lighting and HVAC settings based on real-time occupancy data or scheduling automated systems to reduce energy consumption during lower of occupancy periods. By focusing on these specific spaces, building managers can achieve significant energy savings while ensuring operational needs are met, thus enhancing sustainability and cost-effectiveness in building operations. The study underscores the importance of integrating technological solutions with behavioural interventions to foster a culture of energy conservation, highlighting practical approaches for enhancing energy efficiency in diverse building environments.

Table 3
Respondents response on area that can make improvement

	Meeting room	Prayer hall	Cafeteria	Office	Pantry	Toilet	Parking Area
Respondent A1	/	/	/	/	/		
Respondent A2	/	/	/	/	/		/
Respondent A3	/	/	/	/	/	/	
Respondent B1	/	/	/	/	/		
Respondent B2	/	/	/	/	/	/	
Respondent B3	/		/	/	/	/	/

4.2.2 Improvement

Based on the respondents' perspectives, there is consensus on several strategies that could enhance the effectiveness of green energy initiatives, applicable not only to their respective buildings but potentially to commercial office buildings across Malaysia. Respondents A1, A3, B1 and B2 advocate for the adoption of inverter appliances to optimize energy consumption. This technology upgrade is seen as a practical step towards improving efficiency and reducing operational costs. Additionally, Respondent A2 proposes enhancing occupant awareness through training programs focused on energy-saving practices, encompassing aspects such as electricity, water and overall resource conservation. As suggested in study done by [5], the person most likely and best suited to oversee the company's green strategy or CSR strategy, is the facility manager. This is because many firms have numerous facilities that contribute significantly to their environmental impact. Respondent B3 underscores the importance of timely maintenance to ensure the reliability and efficiency of building components and equipment. Collectively, these insights highlight a multi-faceted approach involving technological upgrades, educational initiatives and maintenance best

practices aimed at advancing sustainable practices in building management. Future research could explore the scalability and impact of these strategies across a broader range of building types and operational contexts to further inform sustainable building practices nationwide.

4.2.3 Trends Technology

The analysis explores emerging trends and technologies identified by respondents that could enhance energy optimization in commercial buildings, particularly in Malaysia. As in Table 4, a consistent theme across respondents, including A1, A2, A3, B2 and B3, is the implementation of LED lighting systems. LED technology is recognized for its energy efficiency and longevity, making it a preferred choice to reduce electricity consumption during periods of low occupancy. Additionally, respondents A1, A2, A3 and B3 advocate for the adoption of inverter equipment, which enables variable speed operation and enhances energy efficiency in HVAC systems and other appliances. Respondents A1, B1 and B3 also highlight solar technology as a promising solution for generating renewable energy and further optimizing building energy consumption. These technologies represent current best practices in energy management and sustainability, reflecting a strategic alignment with global trends toward green building initiatives. Future research could focus on evaluating the cost-effectiveness and environmental impacts of integrating these technologies into commercial building infrastructures in Malaysia, thereby advancing knowledge and practical applications in sustainable building practices.

Table 4
Respondents response technology for further improve energy optimization

	Inverter Appliances	LED Lighting System	Building Automation System (BAS)	Auto sensor	Solar
Respondent A1	/	/			/
Respondent A2	/	/			
Respondent A3	/	/			
Respondent B1			/		/
Respondent B2		/		/	
Respondent B3		/		/	/

Qualitative data has been used for this objective research where interviews have been conducted to obtain data about the recommendation of the best practices of green strategy. The implementation of energy optimization strategies in commercial office buildings, especially during lower occupancy is vital for reducing energy use, operational costs and environmental impact. This study has explored various approaches, including the implementation of advanced technologies such as BAS, LED lighting systems and other technologies. The findings show that technology and occupant engagement can help and significantly enhance energy efficiency and lead to sustainable building performance.

4.3 Building Automation System (BAS)

The integration of BAS in commercial office buildings suggestions comprehensive control over various building systems. With leveraging real-time data and occupancy patterns, BAS can help to adjust settings, lighting and other building services system to reduce energy consumption during lower of occupancy. The capability to automate these adjustments minimizes energy wastage and

operational costs while keep occupant comfort. The findings from the interview indicated and highlighted its potential for adaptability to evolving building needs.

4.4 Light-Emitting Diodes (LED) Lighting Systems

Another is the substitution of traditional lamps and lighting equipment with LED lighting systems. As to illumination, LEDs have substantial advantages in terms of energy consumption and service life as compared to traditional lighting fixtures. Due to the capability of LEDs to adapt the amount of light that is being emitted in response to the availability of natural light and the presence of people, LED lighting system can reduce energy consumption by a large margin when used in tandem with smart controllers and daylight harvesting devices. Therefore, understanding the effects of LED lightings in reducing the maintenance and energy use costs can increase the sustainability levels of the buildings.

4.5 Motion Sensor Technology

There is one significant method through which commercial office buildings can best capture and use energy, and this is through the integration of motion sensor technology. These sensors help decrease energy consumption, especially when spaces are not occupied since it facilitates the control of lights and HVAC to come on only when the area is occupied. Motion sensors are a safe way to reduce energy consumption and according to the respondent, they are cheap and easy to implement.

4.6 Community Participation and Education

The study also underscores the need to engage the community in contributing to energy optimization initiatives and provide education. Besides, technology solutions for efficient utilization of energy there are the approaches based on the education of the building occupants, the efficiency of the energy usage and sustainable behaviours. This in turn means that the methods of organizing tenant engagement in the efficiency of energy use like provision of incentives and signs will enhance the methods if properly employed. The focus of this study does not take an approach where all spaces are compared but rather focuses on parts within buildings which makes it unique from other similar studies. Previous work often aimed at achieving the optimum energy utilization in any area, regions of PABX sections and server rooms where air cooling is always necessary. As it compares with typical methods, which mainly focus on average density in the entire building, this research provides a more precise way in energy management for high-occupancy fluctuation spaces like offices, cafeterias, meeting rooms and eating pantries. Such things as changes in occupant behaviours and interactions, impacts of different designs of the buildings, or even differences in the efficiency of the current building infrastructures are some of the elements that would possibly affect the results of the study, but were not considered in this study. In addition, issues of seasonality, that may affect the utilization of energy and other factors that exist in the external environment where the research was conducted were outside the purview of this research. Furthermore, this research did not take into consideration factors such as the intensity of climatic conditions and weather conditions since they can trigger variations in energy consumption levels. The outcomes support this premise through proving that occupants must be engaged, and technology strategies contribute to achieving optimal building performance. This was supported by a marked decrease in the reduction of efficient energy usage through the installation of BAS, LED lighting and motion sensors as forecasted in the predictions. Also, the role of educating the community as well as its engagement in energy-efficient processes brings credit to the idea as competent and active residents make a significant difference. While the

proposed study modifications could be seen as deviating from some previous research approaches, this focus on certain high-impact areas rather than including the entire building is ultimately well-suited to this specific scenario.

5. Conclusions

The findings show that technology and occupant engagement can help significantly enhance energy efficiency and lead to sustainable building performance. In the result of the area that needs to focus on improvement regarding energy optimization and saving, the data showed that the meeting room, cafeteria, office and pantry were the most suitable places to focus in this study. Research objectives indicate to recommend the best practice of green strategy to implement in commercial office buildings during lower occupancy periods.

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