TRANSITION TOWARDS GREEN FACILITY MANAGEMENT: BRIDGING THE KNOWLEDGE GAPS OF FACILITIES MANAGERS

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ABSTRACT

The building industry has experienced a widespread transition towards green buildings and consequently a growing need for green facilities professionals to maximize green building potential in terms of energy efficiency, water conservation and waste reduction in their operational stage. Green buildings have unique technological systems that require facility managers to have relevant knowledge and skills to conduct proper facilities management and maintenance planning to maximize the potential of green buildings. It is important, then, to investigate whether knowledge gaps for facility managers exist with respect to green buildings, and if so, how these knowledge gaps could be bridged. Though several studies have investigated the operation and maintenance processes of green buildings, few studies considered facility managers' knowledge and skills regarding green facility management (GFM). Set in the context of Singapore, this study aims to holistically investigate the knowledge and skills of managing green buildings in the community of facility managers, including their perceived differences between green and conventional buildings, the difficulty of GFM, the knowledge gaps of GFM and the underlying reasons, as well as how the gaps could be bridged. A total of 90 survey responses were collected and eight interviews with key stakeholders were conducted, which indicate facility managers believe green buildings do have special features that require unique knowledge and skills, and currently knowledge gaps do exist hindering the transition towards GFM. Therefore, this paper derives plausible solutions to bridge the knowledge gaps, such as establishing holistic subsidies for those facility managers participating in training programs of GFM. This study provides references for researchers and relevant governmental departments to better understand industry professionals' knowledge gaps in the transitioning process towards a green built environment, and to make better policy decisions bridging the knowledge gaps and thereby facilitating the green transition process.

KEYWORDS

facilities management, green buildings, Green Mark, knowledge gap, transition

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1. INTRODUCTION

Buildings serve several needs of society, such as providing a place of comfort and safety for people. They come in different forms and functions, addressing residential, industrial, and commercial needs. It is important to ensure that building facilities are well maintained through the process of facilities management to achieve those needs. A green building is one whose construction and operation lifecycle assures the healthiest possible environment, while using the most efficient and least disruptive use of land, water, energy and resources (Klufallah et al., 2014). However, even if a green building was designed and constructed to achieve those aims, it would not have such an impact in the long-term if there is improper facilities management. It is often the case that when building construction is completed, building owners or managers tend to overlook operations and management aspects.

Studies over the years have identified and illustrated the importance of green buildings, yet few addressed the need for proper facilities management after the building construction phase. According to the International Facility Management Association (IFMA), facilities management is defined as a profession which encompasses multiple disciplines to ensure functionality of the built environment by integrating people, place, process and technology (IFMA (International Facility Management Association), 2017b). The IFMA highlighted the fact that facilities management is not limited to the running and maintenance of buildings, but also involves people and ongoing operational processes, making it an iterative process. As such, facilities managers need to provide constant involvement regarding managing a building's operation and maintenance, needs, and delivery. Green facility management (GFM), also known as sustainable facilities management, embodies a similar concept, but reflects the understanding that green buildings have different processes and assets than that of a non-green building. Green buildings consist of various green technologies such as energy management systems, solar roofs, and light-emitting diode lighting systems, making buildings more innovative and sustainable. To undertake green building management, a facilities manager should have the necessary green skills and knowledge to ensure that proper operation and maintenance of the green building, especially the various green technologies, is conducted.

However, green building designs and technologies are very often not communicated to the facilities management team during handover. Most green buildings place more focus on design, material selection, and construction technology, while the operations and maintenance (O&M) aspect often remains neglected (Mohammad et al., 2014). Consequently, regular maintenance is often imposed on green buildings without adequate consideration of the proper functioning of green building systems, which significantly weakens the environmental performance of green buildings. Without the necessary green skills and knowledge, it is almost impossible for facility managers to conduct GFM. Several studies have indicated that knowledge gaps exist for facilities managers regarding green buildings, such as International Labour Organization (ILO) (2011) and Elmualim et al. (2010). However, these studies did not investigate the mechanisms leading to and the potential solutions to bridge the knowledge gaps in a holistic approach. A series of important questions remain to be answered, such as how facilities managers perceive the differences between green and conventional buildings; whether these percieved differences could lead to difficulties and knowledge gaps in GFM; what impacts these knowledge gaps in GFM could lead to with green buildings; and how these knowledge gaps could be bridged.

In the context of Singapore, the number of green buildings in Singapore—constructed or retrofitted—is rapidly increasing due to the introduction of the Green Mark scheme. The Building and Construction Authority (BCA), a statutory board under the Ministry of National

Development, spearheaded the transition towards a green built environment. BCA has also proactively promoted training programs for GFM. However, in practice, very little is known about whether facilities managers understand the differences between green and non-green buildings, as well as whether there are knowledge gaps about green buildings for facilities managers in Singapore. By taking Singapore as an example, this study aims to identify facilities managers' perceived differences between green and conventional buildings, the difficulty of GFM, the knowledge gaps of GFM and the underlying reasons, and how the gaps could be bridged, thereby shedding light on the understanding of industry professionals' knowledge gaps in the transitioning process towards a green built environment.

2. LITERATURE REVIEW

2.1 GFM

The role of a facilities manager is to oversee the entire operation and maintenance process and often has great influence over a facility's entire operation life cycle (Hodges, 2005). There are various responsibilities a facilities manager should fulfill, and they typically include a wide range of operation, maintenance and support services. These responsibilities apply whether one is managing a non-green or green building. However, when managing green buildings and facilities, existing studies suggest there are certain differentiations in duties a facilities manager has to take note of. Typically, green buildings consist of green technologies and features aimed at minimizing energy consumption, waste generation and water consumption, and reducing the operational cost of the building. Yet the benefits of green buildings and sustainability can only be realized with proper facilities management. For instance, green roofs, with a vegetative layer grown or planted on a rooftop, have many benefits, such as reduced energy consumption and temperatures of roof surfaces, and typically have a longer lifespan compared to conventional roofing materials (Environmental Protection Agency (EPA), 2017). Nonetheless, proper maintenance is required in the form of periodic landscape trimming of plants and maintenance of the storm water drainage system. Similarly, green building maintenance can expose facilities managers and workers to health and safety hazards that were previously not in consideration, such as work-at-height risks involved in the installation and maintenance of solar panels on the roof. This indicates the need to tailor facilities management procedures according to green building needs that is carried out by people with the right knowledge and skills set, rather than imposing generic facilities management models on green buildings and expecting to reap the same outcomes.

GFM conducted by facilities managers with the right skills set can create long-lasting value to the building. Defined in the National Green Skills Agreement endorsed by the Council of Australian Governments, green skills are the skills, knowledge, values and attitudes needed in the workforce to develop and support sustainable social, economic and environmental outcomes in business, industry and the community (National Centre for Vocational Education Research, 2013). The ideal GFM should (1) integrate human factors, sustainable facilities, along with green processes and technology aspects of a building; (2) enhance green operations and maintenance management, while optimizing user productivity; and (3) maximize total green building potential in terms of improving energy efficiency, environmental quality, reducing water consumption, and other benefits. Not every facilities manager possesses the skills set necessary to maintain green buildings and facilities. A lack of green knowledge and skills can

prevent facilities managers from conducting their jobs efficiently and hinder the achievement of a green building's potential. Existing studies suggest organizations are still managing green buildings with poorly skilled facilities managers and improper procedures (Min et al., 2016). They either failed to comprehend the differences between non-green and GFM, or simply refuse to send their employees for green certification courses, with reasons attributed to time and costs.

2.2 Knowledge gaps in GFM

Studies have highlighted the crucial role of facilities managers in the transition towards greener and more sustainable buildings and suggested that a lack of knowledge is a crucial factor leading to the unsuccessful implementation of GFM. In 2011, the International Labour Organization (ILO) conducted a study on the skills and occupational needs in green building, which covered over 30 countries and was supported by the European Union (EU). The research showed that there is a substantial shortage and insufficiency in the skills required for green buildings at the operational level; for instance, the installation and maintenance green building technologies (International Labour Organization (ILO), 2011). The sample of countries included in ILO's research consists of both developed and less developed countries. In these countries, including Singapore, a green skills gaps are mainly a consequence of a rapid transition towards greening buildings and continuing advancements in green building technologies changing skills requirements faster than the training systems have responded (International Labour Organization (ILO), 2011).

A total of 86% of architecture/engineering firms and 91% of general contractors reported that skilled green employees were difficult to hire (American Society for Training & Development, 2012). Elmualim et al. (2010) investigated facilities managers' experiences in the United Kingdom in regards to the implementation of GFM policies and practices. The study was conducted among 251 facilities managers, and the results identified time constraints, lack of knowledge, and lack of senior management commitment as the three main hurdles to GFM practice. Similarly, Ikediashi et al. (2012) assessed the state of GFM and investigated the barriers faced in the successful implementation of GFM practices in Nigeria. The authors noted the pivotal role governments play in improving the practice of GFM, along with findings that revealed the shortage of training and tools, lack of relevant laws and regulation, and lack of awareness, as three main barriers of the industry (Ikediashi et al., 2012). Faulty maintenance has been identified as a critical factor leading to O&M problems in green buildings (Mohammad et al., 2014). However, this study did not address what lead to faulty maintenance which could be caused by various factors, such as facilities managers' lack of green skills and the knowledge required to repair malfunctioning machines and equipment.

While a building may be sustainable regarding its design and construction, it can only remain so if it is managed properly and maintained appropriately (Whole Building Design Guide Sustainable Committee, 2016), by facility personnel with the correct skills set. Green buildings require careful operation and maintenance management plans to enhance their productivity performance, and adequate green knowledge and skills are essential in ensuring that every characteristic of green buildings is integrated into the O&M phase. Hence, without facility managers possessing the necessary set of green skills, there will be improper maintenance practices or plans that cost organizations money and time. This not only applies to newly constructed green buildings but also buildings with retrofitted green facilities and systems.

2.3 Bridging knowledge gaps of GFM in Singapore

In 2005, the BCA Green Mark scheme was implemented, and it serves as a green building rating system for newly constructed buildings (Building and Construction Authority of Singapore, 2017). A target to have at least 80% of buildings in Singapore Green Mark Certified by 2030 was set in the second Green Building Master plan, alongside other initiatives such as incentive schemes aimed at green retrofitting existing buildings. As a result of these schemes, there has been an increasing number of green buildings in Singapore, but a lack of facilities managers with the appropriate knowledge and skills set to manage them. To address this problem, the BCA Academy introduced a range of training programs and Green Mark certification courses, to build and enhance the capabilities in operation and maintenance of green buildings (Building and Construction Authority of Singapore, 2013). The Academy aimed to train 20,000 green specialists at the professional, manager, engineer and technician level by 2020 (Building and Construction Authority of Singapore, 2013).

Additionally, with reference to the Finance Circular issued by the Ministry of Finance titled: 'Public Sector to take the lead on Environmental Sustainability', government agencies such as the National Environment Agency (NEA) were encouraged to incorporate sustainability practices into buildings and drive energy efficiency improvements (National Environment Agency, 2013). As the building industry continues to evolve and adopt greener practices, the facilities management industry progresses as well, and facilities managers need to keep up with the latest green technologies and practices in water and waste management, and energy efficiency. With that in mind, NEA introduced a "Sustainability Management Programme for Public Sector's Facilities Managers of Small Buildings" aimed at equipping partakers with green knowledge and skills sets to better manage their buildings (National Environment Agency, 2013).

Apart from BCA and NEA's efforts, the International Facilities Management Association (IFMA) Singapore Chapter has also been working actively with BCA to actively promote a knowledge-based facilities management industry. In April 2010, during the first BCA-IFMA Facilities Management Conference, a memorandum of understanding was signed between IFMA and BCA to explore further opportunities for local facilities managers to participate in endeavors with the building and construction industry. In order to facilitate the shift from non-green to green buildings, IFMA introduced the Sustainability Facility Professional (SFP) credential program in 2011, an assessment-based specialty credential in sustainability (IFMA (International Facility Management Association), 2017a). The SFP credential encourages facilities managers to grow their sustainability knowledge and gain more expertise in GFM practices by focusing on three areas—Strategy and Alignment for Sustainable Facility Management, Managing Sustainable Facilities, and Operating Sustainable Facilities. The program also allows facilities managers to gain essential knowledge on how to improve the sustainability of their facilities in eight major categories of GFM—energy, water, materials and resources, workplace management, indoor environmental quality, quality of services, waste and site impact (IFMA (International Facility Management Association), 2017a). Being a key stakeholder in the building industry, IFMA plays an integral part in the integration of sustainability efforts in the management of buildings and facilities, as well as preparing facilities managers for the shift towards greener buildings.

Despite these efforts, it is not compulsory to sign up for these courses and facilities managers could be unwilling to upgrade their green skills due to time and cost. The demand for

green professionals is rapidly increasing. The constant advancements in green technology, as well as green building construction and retrofitting schemes could make it difficult for training systems to adequately educate a sufficient number of facilities managers. While advancements in green technology should be encouraged, this, in turn, affects various attempts to bridge the green skills gap, and the building industry is faced with the challenge of keeping up with the industry's skills needs and demands.

The literature review indicates that because of the green technologies employed such as green roofs and solar panels, green buildings need tailored rather than generic facility management procedures and knowledge. Previous studies on GFM, such as Elmualim et al. (2010) and Ikediashi et al. (2012), have noted the issue of knowledge gaps for facilities managers, but these studies do not identify potential measures to bridge the facilities managers' knowledge gaps in GFM. The review of Singapore's efforts in promoting GFM indicates that even though various institutions in Singapore, such as the BCA Academy, NEA and IFMA, have implemented various training programs and measures to popularize GFM for facilities managers, it remains uncertain how facilities managers perceive these training programs and whether they are willing to attend these programs due to time and monetary constraints. Thus, the literature review suggests that there is a lack of research on the presence of green skills and knowledge gaps for facilities managers. This study aims to investigate the knowledge gaps among facilities managers in a systematic approach by identifying facilities managers' perceived differences between green and conventional buildings, the difficulty of GFM, the knowledge gaps of GFM and the underlying reasons, and how the gaps could be bridged, thereby facilitating the transitioning process towards GFM.

3. RESEARCH METHODOLOGY

This study develops a research procedure and associated research hypotheses, followed by the gathering of both qualitative and quantitative data, which is achieved through a questionnaire survey completed by local facilities managers as well as interviewing both government officials and facilities managers. Survey data were analyzed via descriptive statistics and one sample t-test, while content analysis was used to treat the qualitative interview data. The use of both qualitative and quantitative data enables cross-validation and guarantees a more thorough research.

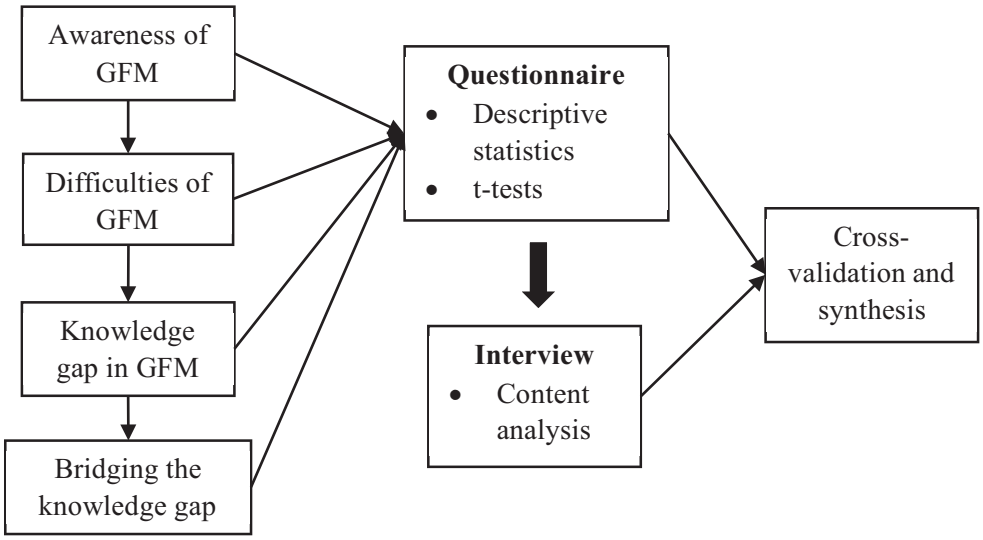
3.1 Research procedure and hypothesis development

Figure 1 demonstrates the research procedure of this study. Based on the literature review, this study develops six hypotheses to test the awareness, difficulties and knowledge gaps of GFM, as shown in Table 1. To test the six hypotheses, a one sample t-test with a significance level of 0.05 was adopted, and a questionnaire survey was developed to collect quantitative data for the testing. After the questionnaire survey, interviews were conducted to allow questionnaire respondents, as well as newly invited government officials, to further comment on the current status and knowledge gaps in GFM. The results of the questionnaire survey and interviews were then compared and synthesized to allow cross-validation. The details of the questionnaire survey and interviews are explained in the following subsections.

3.2 Questionnaire survey

For quantitative data collection, a survey questionnaire was conducted in order to capitalize on the expertise of local facilities managers. The questions in the questionnaire were developed

FIGURE 1. Research procedure and methods.



based on the implications of the literature review and the research aim of this study. Since this study aims to identify facilities managers' perceived differences between green and conventional buildings, the difficulty of GFM, the knowledge gaps of GFM and the underlying reasons, and how the gaps could be bridged, the questions in the questionnaire cover these major aspects. Furthermore, to provide data for the six hypotheses listed in Table 1, the questionnaire developed also needs to include six questions that specifically correspond to the six hypotheses respectively. The questionnaire should also consider the Singapore context to make it specifically relevant to facilities managers in Singapore. The final questionnaire consists of a total of

TABLE 1. List of research hypotheses.

Category	Code	Hypothesis
Awareness of GFM	H_1	The key to a successful green building **lies largely in proper facilities management**, and not solely to its design and construction.
	H_2	There is **a difference** between non-green and GFM.
Difficulties of GFM	H_3	Green buildings with certain architectural features, such as light shelves, vertical greenery systems, and shading devices **face** greater maintenance difficulties.
Knowledge gap in GFM	H_4	The facilities management sector **faces** a green skills gap in terms of the transition from managing non-green to green buildings.
	H_5	Inadequate knowledge and skills set to manage green building systems and technologies **can lead** to early system failures.
	H_6	Inadequate knowledge and skills set **will result** in underperforming green buildings during the O&M stage.

22 questions distributed in 4 sections, including 1) general knowledge of facilities manager; 2) facilities management; 3) the importance of green knowledge and skills set; and 4) green skills training, the details of which are as follows.

- In Section A, the general knowledge and background of the respondents were obtained, which aims to understand how many of the survey participants have experience in managing both green and non-green buildings, and the green certifications they possess.
- In Section B, questions address the differences between green and non-green buildings, and green maintenance difficulties. In this section, the hypotheses H1, H2 and H3 were tested.
- In Section C, the consequences of inadequate green skills and knowledge were investigated. This facilitates the understanding of the significance of green knowledge and skills set, underpinning the importance of encouraging facilities managers to attend green certification courses. In this section, the hypotheses H4, H5, H6 were tested.
- In Section D, respondents were required to answer questions related to green skills training, such as the costs they are willing to dedicate to personal work skills development that bridge the green skills gap.

Likert Scale questions, which measure attitudes and opinions, form most of the questions. Respondents were required to indicate how much they agree or disagree with a statement, or rank various factors impacting GFM based on a five-point Likert scale as shown in Table 2. All the hypotheses listed in Table 1 were captured in Likert scale questions and tested using t-tests. As shown in Table 2, since the score of 3 denotes "neutral/ moderately impactful," the t-tests in this study were set to determine whether the sample mean of the hypotheses questions varies from the tested value, in this case, 3, significantly. If the sample means were tested to be significantly larger than 3, it means the statement in the corresponding question was supported. Otherwise, the statement would be rejected. A similar approach has been utilized by previous studies such as Darko et al. (2017).

The use of parametric statistics to analyze Likert scale data is widely employed in existing studies. The idea of banning the use of parametric analyses for scale data, with the argument that scale data is ordinal and thus can only be analyzed with nonparametric statistics, is overly restrictive as many methods, such as factor analysis used to develop scales, are based on parametric statistics (Harpe, 2015). Individual rating items with numerical response formats with at

TABLE 2. Likert scale–linguistic terms.

Anchors	Linguistic Terms
5	Strongly Agree/Very Impactful
4	Agree/Somewhat Impactful
3	Neutral/Moderately Impactful
2	Disagree/Lightly Impactful
1	Strongly Disagree/Least Impactful

least five categories in length could be treated as continuous data (Harpe, 2015). For instance, Michelsen and Madlener (2017) studied the influencing factors for homeowner satisfaction with low-carbon heating technologies by using t-test to examine the Likert scale data collected from a questionnaire survey. Similarly, Darko et al. (2017) identified the significant drivers for implementing green building technologies by using t-test analysis. In this study, a five-point Likert scale is used, and if the mean value of a certain driver is found to be significantly larger than 3.5, the factor will be considered as a significant driver. Other examples of using a t-test to analyze Likert-scale data include Kalsoom and Khanam (2017). To summarize, it is widely accepted that data from a Likert scale could be analyzed through parametric texts such as a t-test.

The target audiences for the survey questionnaire are professionals from the facilities management industry. To ensure that there is a right mix of industry experts with experiences in conventional and GFM, there was a need to identify certified green professionals in Singapore so that they can be included in the sample. As such, lists of certified Green Mark Managers (GMM), GMFM and Green Mark Professionals (GMP) obtained from BCA were examined to identify suitable participating organizations. A consolidated number of BCA certified green professionals can be found in Table 3.

Concerning all three lists, participating companies were then selected and compiled so that the sample included certified green facilities managers with the necessary knowledge to manage green buildings and facilities. Company sectors were also taken into account to ensure that they belong to one of the following sectors—facilities management, real estate and properties, design/engineering, contractors and developers. Though not all facilities managers in the selected companies are certified, this sampling method ensured that the sample included companies with at least one green certified professional.

The online survey was launched in September via Qualtrics and closed in January after 90 responses were collected. Electronic mail was used as the main channel to disseminate the survey link. To achieve the highest response rate possible, as well as sorting for permission, a preliminary electronic mail was sent to organizations' facility management departments; the emails of which are obtained from the official websites of the organizations. The preliminary electronic mail consisted of an authorization letter obtained from the Department of Building at NUS, the purpose of the research study and a softcopy of the survey. This allowed the facility management department to go through the survey first, a procedure many organizations required and adhered to. After approval, the organizations were asked to provide the contacts of potential respondents from their organizations, and an electronic mail containing the actual survey link was sent to suggested participants from the facilities and property management teams/departments.

TABLE 3. Total number of BCA certified green professionals.

Certification	Number of Certified Personnel	As of
Green Mark Manager	704	15 July 2015
Green Mark Facilities Manager	140	3 August 2015
Green Mark Professional	67	15 July 2015
Total	911	

3.3 Face-To-Face and Phone Interviews

Face-to-face and phone interview approaches were adopted as a means of qualitative data collection method, which helps to eliminate ambiguity and provide the opportunity for interviewees to express their opinions when answering survey questions. Six follow-up interviews were conducted with survey respondents who were willing to participate in the interviews and selected as experienced facilities management professionals. Further, an additional 2 interviews were conducted with representatives of a statutory board that regulates and plays a crucial role in the promotion of GFM. Among these eight interviews, 3 were face-to-face interviews, while five were implemented by phone due to participants' schedule constraints. As the representatives of a statutory board of the building industry, interviewee A and B both provided insights for the development of governmental policies, as well as the thought process and rationality behind the green certification courses offered.

Amongst the six interviewees selected from the questionnaire respondents, 4 of them were BCA certified green professionals—3 Green Mark Facilities Manager (GMFM), and 1 Green Mark Manager (GMM), while two are non-certified. By conducting follow-up interviews with these two groups of people, a deeper understanding of the different knowledge bases possessed between certified and non-certified individuals can be attained. Additionally, through the interview process, the current efforts made by key stakeholders can be identified. The profiles of the 8 interviewees are provided in Table 4.

The interview data was dictated and subsequently analyzed by content analysis. Qualitative content analysis focuses on the contextual meaning of the text, with the text in verbal, print or electronic form (Hsieh & Shannon, 2005). There are three types of qualitative content analysis, namely, conventional content analysis, directed content analysis and summative content analysis (Hsieh & Shannon, 2005). In this study, directed content analysis was used to analyze the interview data. In directed content analysis, researchers use existing theory to identify key

TABLE 4. Profiles of the interviewees.

Code	Job Title	Job Function	Type
A*	Senior Manager of Green Mark Department (Existing Buildings) and Technology Development Group	Green Technology	Face-to-face interview
B*	Director of School of Graduate Development & Management	Academic and Administration	Phone interview
C	Facilities Management Specialist	Facilities Management	Face-to-face interview
D	Senior Facilities Management Planning Infrastructure Officer	Facilities Management	Face-to-face interview
E	Assistant General Manager	Facilities Management	Phone interview
F	Facilities Engineer	Facilities Management	Phone interview
G	Executive Property Manager	Facilities Management	Phone interview
H	Facilities Management Specialist	Facilities Management	Phone interview

concepts as coding categories. Directed content analysis can also be referred to as deductive content analysis, based on how the interview transcripts in this study were categorized into awareness, difficulties, knowledge gaps and bridging knowledge gaps of GFM, corresponding to the questionnaire structure. The interview results and the questionnaire results were then able to be compared and cross-validated.

4. RESEARCH RESULTS

4.1 Respondents profile and result overview

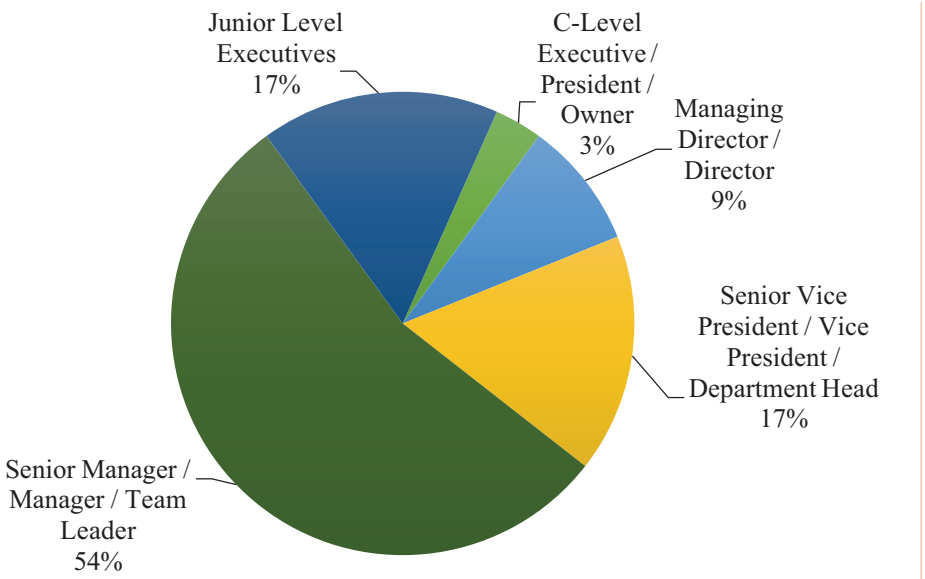
A total of 280 emails were sent out to selected participating organizations from the private and public sector, and a total of 121 responses were obtained. Out of 121 survey responses, 31 were incomplete and hence excluded from the sample, further ensuring the accuracy of the statistical results. A total 32.1% response rate was achieved. As shown in Table 5, the survey was disseminated to the facilities management department of companies from different sectors, obtaining a more diverse pool of respondents. A large proportion of respondents (47.8%) have more than 10 years of experience in traditional facilities management and none had less than one year or no experience. Comparatively, the proportion of respondents that possess more than 10 years of experience in GFM is smaller (10%), and the majority (41.1%) fell under the category of 5–10 years of experience. This could be explained by the fact that green buildings only started to gain momentum in the local building industry in 2005 when the Green Mark Scheme was launched. Hence, most facilities managers will naturally have more experience in conventional facilities management as compared to GFM.

Facilities management professionals with experience in both conventional and GFM are more likely to understand the differences between non-green and green buildings. A total of 84 survey respondents (96%) have experience in both non-green and GFM. Therefore, they

TABLE 5. Participating companies' profile–sector/industry.

Sector / Industry	Number of Respondents	Percentage
Contractors	3	3.3%
Real Estate & Properties / Developers	15	16.7%
Design / Engineering	5	5.6%
Facilities Management (General)	45	50.0%
Facilities Management (Specialised)		
Healthcare	5	5.6%
Mining	2	2.2%
Financial Institutions	4	4.4%
Attractions / Tourism	3	3.3%
Educational Institutions	8	8.9%
Total	90	100%

FIGURE 2. Participating respondents' percentage profile—job level.



are able to provide more accurate and valuable responses during the process of survey collection. Participating respondents were also categorized based on their job levels, and 49 of them (54%) belonged to the Senior Manager/Manager/Team Leader level, as shown in Figure 2. Out of these 49 respondents, 17 are senior managers and 32 are managers.

As shown in Table 6, the statistical analysis reveals that all means of the hypothesis questions are greater than the test value of 3, indicating that in general, the majority of the respondents

TABLE 6. Likert scale questions—one sample t-test.

	Test Value = 3						
	Mean	Std. Deviation	Std. Error Mean	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
						Lower	Upper
H1	4.07	.761	.080*	.000**	1.067	.91	1.23
H2	4.10	.542	.057*	.000**	1.100	.99	1.21
H3	4.11	.608	.064*	.000**	1.111	.98	1.24
H4	4.07	.650	.069*	.000**	1.067	.93	1.20
H5	4.17	.604	.064*	.000**	1.167	1.04	1.29
H7	4.33	.561	.059*	.000**	1.333	1.22	1.45

(For all data, $N = 90$ and $df = 89$)

*Standard error mean is very small.

**With a significance level of 0.05, the one sample t-test is significant (test-value = 3).

agree with the questions' context. Since a one-tailed one sample t-test is required and the results generated by SPSS statistics are of two-tailed significance, to convert the two-tailed test into a one-tailed test, the output p-value is thus divided by half. This calculation method is subsequently applied to all results generated by SPSS. The one-sample t-test is significant at a significance level of 0.05. The standard error of the means (SEMs) are also investigated as they allow us to validate the data sample, serving as an estimate of how far the sample mean is likely to be from the population mean (Lee et al., 2015). SEM is calculated by dividing the sample standard deviation by the square root of the sample size, and as sample size increases, the magnitude of the standard error decreases. Therefore, the smaller the SEM, the more accurate the statistics are, indicating a more accurate estimate of the parametric mean (Lee et al., 2015). Since the SEMs are very small, it signifies a rather precise estimate of the population.

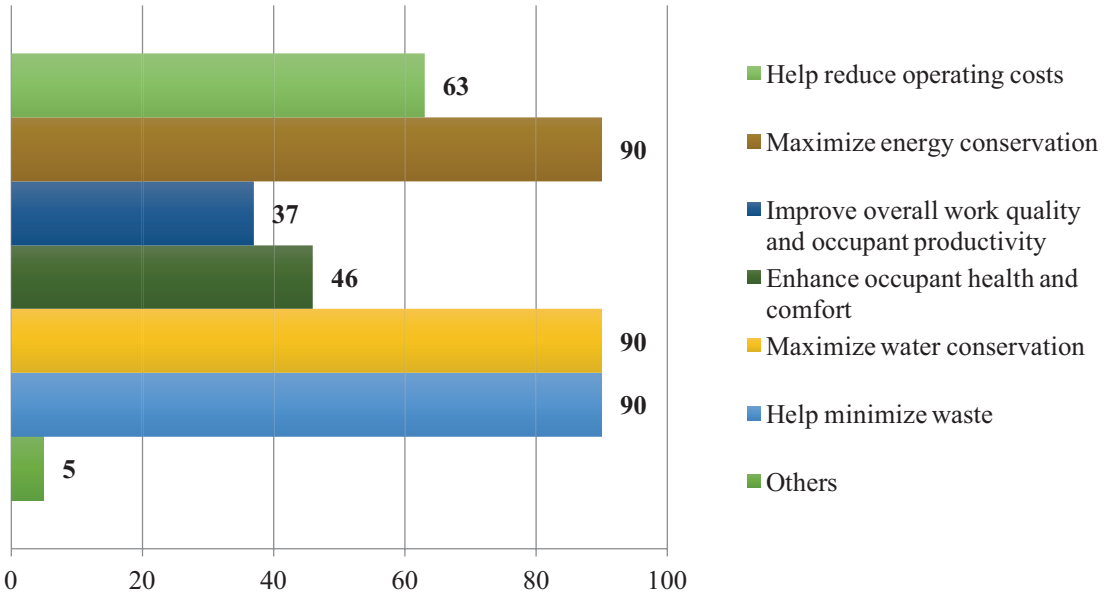
The following sub-sections illustrate the research results in detail, including the awareness of facility management for green buildings, the difficulties of GFM, the knowledge gaps of GFM and potential measures to bridge the knowledge gaps.

4.2 Awareness of facility management for green buildings

Green buildings have great potential in bringing about tangible and intangible benefits, such as energy and water savings, minimizing waste, improving overall work quality (Miller et al., 2009), and enhancing occupant health and comfort (Kats, 2003). A multiple-choice question was designed to investigate how facilities managers understand the benefits of green buildings. As shown in Figure 3, all 90 respondents agreed that a green building should help maximize energy and water conservation, as well as help minimize waste. By contrast, a smaller number of respondents, ranging from 37 to 63, felt that green buildings should also help to reduce operating costs, improve work quality and occupant productivity, as well as enhance occupant health and comfort. This reflects most facilities managers belief that green buildings are more about environmental sustainability than social and economic sustainability. Specific to building characteristics, one of the most distinct differences between non-green and green buildings, according to interviewees A and C, is regarding energy efficiency and energy usage. Interviewee A further indicated that apart from green buildings, when a conventional building undergoes green retrofits, benefits generally come in the form of energy savings, and the energy spending will, in most cases, go down, unless there is a major change in the use of the building.

After identifying the benefits of green buildings, respondents were asked to identify other differences between green and non-green buildings. Participants agree, 27.8% and 26.7%, that green buildings cost more, as well as require more time to maintain than conventional buildings, while 34.4% and 48.9% of participants disagree with these statements respectively. Only 11.1% of the respondents agree that green buildings require more manpower than non-green buildings, while 37.8% of them disagree with the statement, and 45.6% feel neutral about it. These results highlight that Singapore facilities managers generally do not perceive green buildings as resource intensive, namely requiring more investment, time and human resource. This contrasts with several other studies such as Shi et al. (2013) and Hakkinen and Belloni (2011), where green buildings are regarded as the resource intensive types of buildings. Out of the 90 respondents, 83.3% agree that facilities managers of green buildings require higher technological knowledge than those managing non-green buildings, while 12.2% strongly agree with that statement. Respondents agree (77.8%) that technological systems in green buildings are more complicated to handle than non-green buildings. This highlights that additional knowledge and skills of facilities managers are key differences between conventional and green buildings.

FIGURE 3. Aspects a green building should accomplish/help to achieve.



The first null hypothesis, as indicated in Table 6, is rejected since the p-value is smaller than the predetermined significance level of 0.05. In other words, the statistics indicates that the key to a successful green building lies largely in proper facilities management and cannot solely be attributed to its design and construction. The result supports (Mohammad et al., 2014) who argue that while the design and construction phase is important, the O&M aspect of green buildings should not be neglected.

Regarding the differences between traditional and GFM, the t-test reveals that there is a difference between non-green and GFM. This result aligned with the research conducted by (Collins & Junghans, 2015) regarding the difference in a facilities manager's role when managing conventional and green buildings, and how additional skills are required to manage green buildings. Such a difference mean that the knowledge and skills set used in non-green building management are not entirely applicable in green building management. It is thus important for local facilities managers, as well as organizations, to realize the existing differences between non-green and GFM. As 83 respondents agree/strongly agree with the statement that there is a difference between non-green and GFM, these respondents were then required to state three fundamental differences between non-green and GFM. Energy consumption, use of green building technologies, and a higher level of knowledge were identified to be the three fundamental differences between non-green and GFM. Interviewee C, E and G further commented that the hardware aspects of green buildings can be very different from conventional buildings regarding the architectural features and adopted technologies. For instance, interviewee G has stated that "*a green building would probably have additional "green" equipment as compared to a conventional building, such as solar panels, hot water recovery system, variable speed drive (VSD), electronic ballast, water recycling system, pre-cooled coil, energy efficiency chiller plant with state of the art energy management system. To be able to manage these additional system features, the facilities team must be equipped with the knowledge of these systems in order to carry out proper maintenance to troubleshoot them if these systems breakdown.*" As such, a generic maintenance plan used in conventional buildings will not be fully applicable for green buildings.

4.3 Difficulties of GFM

Since the p-value is smaller than the predetermined significance level of 0.05, the third null hypothesis is rejected as well. This indicates that green buildings with certain green architectural features do indeed face greater maintenance difficulties. Respondents were then required to choose 5 factors out of 7 given factors and rank them from the most impactful to the least impactful according to their impact on green building maintenance difficulties. With a mean of 4.20, "inadequate experience, training and knowledge" is identified as the most critical factors contributing to maintenance difficulties, following which, with a mean of 3.45, "improper maintenance planning/management" is identified as the second most important factor. One possible explanation for this result is that maintenance planning and management is related to the extent of experience, training and knowledge one has. Without the necessary green experience and knowledge, a facilities manager will find it very difficult to effectively conduct maintenance planning and management for green buildings.

Design problems (i.e. disregard for maintainability aspect in design) are also highly recognized by the respondents as an influential factor for maintenance difficulties. With architectural features, such as light shelves, solar panels and vertical greenery, it is ever more important to ensure that maintainability issues are taken into account during the design stage of green buildings. It is vital to note that the design and construction stage is related to the operation and maintenance stage, and they should not be dealt with separately. Interviewee C commented that "*when it comes to design and construction, many organizations have moved forward to include considerations on how to operate eventually, as everything is integrated*." Interviewee C indicates that green certified facilities managers could be recruited into the project team at the start of the planning/design stage. While this is highly recommended, there are no laws or regulations in place to enforce the early involvement of facilities managers in the design stage of a building project. Therefore, it is recommended that both the building and facilities management industry could jointly aim for early involvement of green certified facilities managers at the start of the project's planning and design phase. This will permit discussions on operability and maintainability of various green systems and features to take place at the start of the project, allowing the design team to take these factors into consideration.

4.4 Knowledge gaps in GFM

The fourth null hypothesis is rejected as well, indicating there is a green skills gap in the local facilities management industry. This result supports the observations set out by (Elmualim et al., 2010), reiterating the lack of green knowledge and skills set within the facilities management industry.

The remaining hypotheses aim to describe the consequences of inadequate green knowledge and skills, and the t-tests support these consequences. Specifically, out of the 90 collected responses, a total of 82 facilities management professionals (91.1%) agree/strongly agree that inadequate green knowledge and skills set can lead to early system failures. This observation can be attributed to the fact that a lack of green knowledge and skills set can affect the way facilities managers handle green technologies and systems, and potentially impede the success of green buildings and their performance during the O&M stage. This is further supported by interviewee D, who stated that "*For facilities management in green buildings, we need to be trained to understand certain green features, how do some of these features work and so on. If the facilities manager changes the parameters without proper consideration, it will result in a loss of energy savings, and the building will not be as efficient*." Similarly, interviewee G has indicated that "*the role of*

a facilities manager would be to come out with a good maintenance plan, and to do so, he/she will need to understand the systems, identify breakdown signs and so on. These green system performance and efficiency systems will deteriorate over time and the facilities managers may not even be aware of this degredation if they do not possess some knowledge of these systems."

However, it is also important to note that facilities managers need not possess a whole lot of technical knowledge to manage green buildings. Instead, green technologies and systems are usually maintained and repaired by specialized service providers who possess the necessary technical skills to do so. But, to adequately perform the role of a facilities manager in Singapore, one would need to understand the Green Mark scheme, regulations, green buildings, trends, the basics of green technologies and systems, as well as be able to identify system breakdown signs. With these necessary knowledge and skills set, a facilities manager will then be able to generate a good maintenance plan and adequately manage green facilities.

Green buildings typically consist of various advanced building technologies such as an expansive rectilinear roof—a distinctive feature found in Changi Terminal 3—which can help buildings save energy. Some of these green building technologies incur a sizeable upfront cost, and it is imperative for facilities managers to properly operate and maintain these technologies to maximize their life cycle performance. Globally, millions of conventional buildings underwent green retrofits in bids to cut down on energy use and reduce greenhouse gas emissions (Biello, 2011), and Singapore is no exception. Interviewee A has particularly highlighted that green retrofits are economically feasible only when energy savings after retrofits could offset the initial investment on the retrofit, and to sustain green buildings' level of performance and efficiency after retrofits, the facilities management team have to be equipped with the appropriate knowledge base.

4.5 Bridging the knowledge gaps

Since this study has identified a knowledge gap in GFM, there is a need for facilities managers to upgrade their knowledge, through various avenues such as undertaking green training and certification courses. A total of 77 survey respondents agree/strongly agree that green buildings should be managed by certified facilities management professionals. The extent of facilities managers' awareness of the list of green certification courses offered by BCA, namely GMM, GMFM, and GMP, can affect the demand for the courses. The results indicate that 68.9% of the respondents are aware of all four green certification schemes offered by BCA; 71.1% of them know about at least three schemes, and 91.1% and 98.9% of them are aware of at least two schemes and one scheme respectively. Among all 90 respondents, only one individual indicated a lack of awareness for all green certification courses offered. Thus, it is reasonable to conclude that facilities managers in Singapore have a high level of awareness of the green certification courses offered by BCA, which could be explained by the fact that BCA has continuously taken efforts to popularize these courses in the industry. BCA has continually tried to reach out to organizations and industry professionals through a series of roadshows and conferences, such as the Singapore Construction Productivity Week, International Green Building Conference (IGBC) and BCA Green Office Pop-up.

This study has further investigated which form of training is the most acceptable for facilities managers. The results show that facilities managers prefer to attend classroom or instructor-led training as compared to other training methods. Referring to Figure 4, a majority of respondents (67, 74.4%) favor classroom or instructor-led training, whereby individuals attend courses taught by experienced instructors. Sixteen respondents (17.7%) prefer to attend

computer-based training/online or e-learning, an observation that could be explained due to time constraints, where e-learning platforms offer greater convenience to full-time working adults. Comparatively, hands-on training and self-learning are the least popular training methods, with only 5 and two respondents (5.7% and 2.2%) selecting those options. With hands-on training, facilities managers often have to learn based on experience and rely on their mentors' knowledge. Such a method takes time and relies on the assumption that the knowledge imparted by the mentors is accurate and up-to-date. As such, this could explain why most facilities managers do not prefer to undergo hands-on training and self-learning.

Since most respondents prefer traditional classroom training, the cost to be incurred by facilities managers then is a key variable, which will affect an individual's willingness to attend green certification courses. The results showed that even though the green training and certification courses offered by the major governmental organizations are not compulsory, all 90 respondents (100%) are willing to undergo green training and certification courses if their company was to subsidize the course fees. On the other hand, only 59 respondents (66%) are willing to go for green training and certification courses if the course fees are not subsidized. This corresponds to a 44% decrease in willingness to attend green certification courses between subsidized and non-subsidized course fees. This observation could be explained by the high course fees required for individuals to attend green certification courses. The respondents were then required to indicate an affordable course fee range if they were not subsidized. In contrast to a fee of $1,120 for a typical GMFM certification course under the BCA Academy, the majority of respondents (94%) are unwilling to pay more than $1,000 per course if the course fees are not subsidized. As shown in Figure 5, a total of 59 respondents consider a fee of $200–$500 per course affordable, and only five were willing to pay more than $1,000 per course. The result strongly highlights the need for additional incentives from government or organizations to encourage individuals to enroll in green certification courses.

Though BCA had continually tried to reach out to organizations and individuals regarding the importance of green buildings and green skills upgrading, it is evident from this study that course fees play a huge part in individuals' willingness to attend green certification courses.

FIGURE 4. Training program methods/techniques.

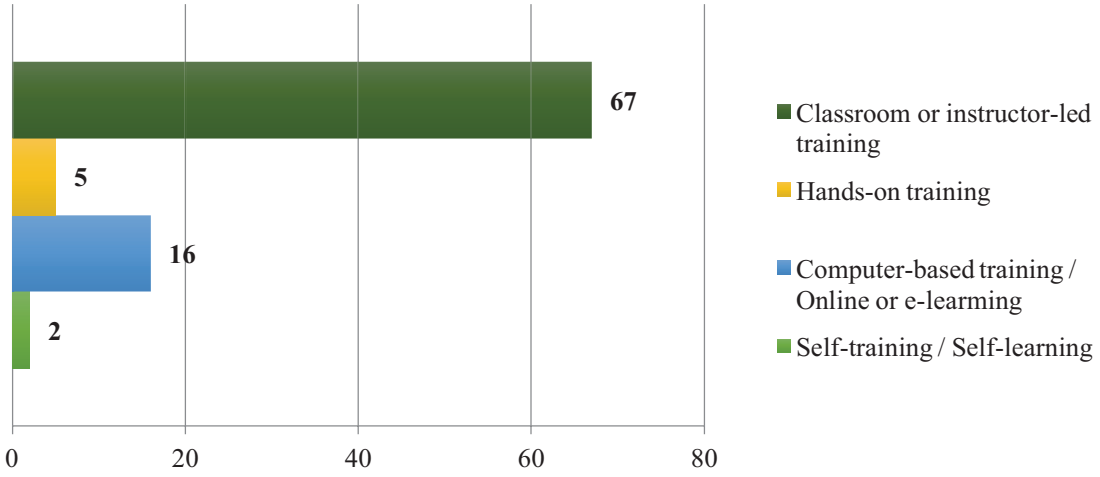
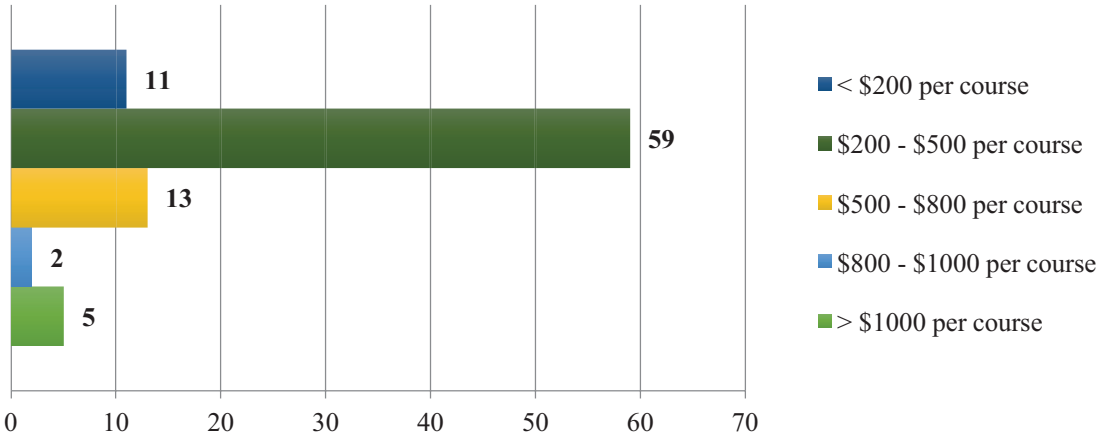


FIGURE 5. Green certification course fee range considered as affordable by individuals.



Presently, there are various funding channels, such as the SkillsFuture Credit scheme under the Singapore Workforce Development Agency (WDA) that makes funding available for individuals who are willing to pay for a portion of their own training. Individuals undertaking green certification courses offered by BCA Academy, a WDA-appointed Continuing Education and Training (CET) Centre, are eligible for funding of up to 70%, 90% or 95% of the course fee according to their age and income level.

For instance, a GMFM course typically cost $1,120 (Building and Construction Authority of Singapore, 2015). In relation to the survey data collected, 94% of the respondents are unwilling to pay more than $1,000 per course, and 66% are willing to only pay a range of $200–500 for green certification courses. As shown in Table 7, considering an age range between 21 to 29,

TABLE 7. Course fee funding for individuals (Workforce Development Agency, 2015).

Category	Type of Course[1]	All Singapore Citizens and Permanent Residents aged ≥ 21 years	Singapore Citizens	
			Aged ≥ 40 years[1]	Aged ≥ 35 years and earning ≤ $1,900/month[2]
Courses offered by WDA-appointed CET Centres	Non-PME-level Courses	Up to 90% of course fees	Up to 90% of course fees	95% of course fees
	PME-level Courses	Up to 70% of course fees		
Certifiable Courses approved by WDA	Non-PME-level Courses	80% of course fees, capped at $17/hour	90% of course fees, capped at $25/hour	95% of course fees
	PME-level Courses	50% of course fees, capped at $15/hour	90% of course fees, capped at $50/hour	

Note: [1] PME indicates Professionals, Managers and Executives

eligible facilities management professionals will be able to get up to 70% funding, and they will only be required to pay a fee of $336, well within the range of $200–500. However, through the interviews, it was noted that while the interviewees knew about the SkillsFuture Credit scheme, few actually knew the procedures to follow to obtain subsidies for self-paying courses. As such, a two-pronged approach is recommended to resolve the issue of inadequate experience, training and knowledge, which includes increasing individuals' awareness of the benefits accrued by attending green certification courses, as well as the funding and subsidies made available to them. Through this approach, facilities management professionals are encouraged to take the initiative to sign up for green training courses.

Additionally, major organizations and associations such as BCA and IFMA should work together and provide a better-rounded learning environment for facilities management professionals. Currently, only WDA certified courses are eligible for funding. As such, course fees of internationally recognized green certification courses such as IFMA's SFP credential program have to be borne by individuals. This not only hinders the demand for such courses, but also diminishes individuals' willingness to advance their green building knowledge due to high course fees. It is thus recommended that training courses offered by other institutions be included in funding schemes.

Despite the recommended short-term plan to increase funding and subsidies for training courses, interviewees indicated that in the long-term GFM should be promoted based on market principles. Interviewee E indicated that "*not every organization is willing to support their staff for green skills development. An organization with a limited budget or one that does not pay much attention to green skills will limit the development of such skills of the facilities management department*." However, interviewees A and H suggested that with the increasing number of green buildings in Singapore, it is expected that developing green buildings will become the mainstream practice in industry and facilities managers have to proactively adjust themselves to service green buildings. Otherwise, they will lose the market to their competitors. Interviewee A has particularly emphasized that facilities managers should have a long-term vision to undertake green certification courses to obtain the first-mover advantage, as he indicated that "*the green building movement has some traction now as more people are getting aware (of the benefits of green buildings), not only just the owners, but also at the professional and technician level. As such, they will see the need to upgrade themselves, so I think people are motivated to get trained*." When the industry of green buildings becomes mainstreamed, without the efforts of BCA to persuade the industry, the competitive market will push reluctant facilities managers to upgrade their knowledge and skills in green buildings. During this transition process to green buildings, BCA should keep up with the development of the industry to ensure that the amount and contents of green certification courses can meet the increasing demand and requirements from facilities managers. Interviewee C has specifically highlighted the importance of constant and continuing learning, stating that "*technologies are always improving and changing. So, you may be a certified GMFM 3 years ago, but 3 years later, the knowledge you have gained may already be outdated. Therefore, you need to constantly upgrade your green building knowledge base, such as attending IGBC or other green refresher courses*."

Interviewees also recommended that a shared professional network for developers, facilities managers, and specialists be established. Apart from individual efforts, it is also important for key stakeholders and industry organizations to transmit the latest green building knowledge and news through various channels such as the International Green Building Conference (IGBC) and shared networks. The existence of a shared network will provide a common platform for

facilities management professionals to share their green knowledge and experience, as well as allow organizations to transmit news on the latest technologies and green building trends, thereby speeding up the learning process of GFM in the industry.

5. CONCLUSION

This study was undertaken to investigate the green knowledge gap in the facilities management industry by taking Singapore as an example, and by exploring plausible solutions that can help bridge the gap through the use of both quantitative (survey questionnaire) and qualitative methods (face-to-face and phone interviews).

It was identified that facilities managers perceive maximizing energy and water conservation and minimizing waste as the most distinctive features of green buildings, which they believe, do not necessarily require incremental costs and human resources. They also believe GFM and traditional facilities management are significantly different because of the unique technological systems used in green buildings which require new knowledge and skills. It has been identified that inadequate experience and knowledge, improper maintenance planning, and a disregard for the maintenance aspect in design are the top three most critical factors leading to difficulties in green facilities management. The t-tests justified that inadequate green skills and knowledge can lead to early system failures and underperforming green buildings during the O&M stage. This study subsequently showed that even though most facilities managers are aware of the various available courses on GFM and prefer the traditional classroom-based training programmes, the lack of willingness to sign up for paid courses without company subsidies was identified to be a critical factor contributing to the limited demand for green certification courses among facilities management professionals.

In order to overcome these problems and encourage more facilities management professionals to sign up for green certification courses, suggestions were proposed including: (1) a two-pronged approach, namely increasing individual's awareness of the benefits accrued in attending green certification courses and the funding or subsidies schemes for individuals; (2) increasing the extent of subsidies coverage to training and certification courses offered by other institutions and associations rather than BCA; (3) ensure the amount and contents of the green certification courses can meet the increasing demand and requirements from facilities managers; and (4) establish a shared network as an information platform for GFM for facilities managers.

Future opportunities exist in this area of research. Considering that there are around 900 certified facilities management professionals in Singapore, and a large pool of uncertified facilities managers, a sample size of 90 may be considered limited. Therefore, future studies could try to increase the sample size, thereby enhancing the representativeness of the study. Furthermore, data collection and findings from this study were interpreted in the context of Singapore. Future studies are recommended to provide a similar analysis illustrating the reasons and impacts of green knowledge and skills gaps in other groups of professionals, such as designers and engineers, and in various countries, allowing for an international comparison of green building knowledge gaps.

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REFERENCES

American Society for Training & Development. (2012). Bridging the skills gap. Retrieved from http://nist.gov/mep/upload/Bridging-the-Skills-Gap_2012.pdf

Biello, D. (2011). How green is my city. *Scientific American, 305*(3), 66–69.

Building and Construction Authority of Singapore. (2013). Leading the way for green buildings in the tropics. Retrieved from https://www.bca.gov.sg/greenmark/others/sg_green_buildings_tropics.pdf

Building and Construction Authority of Singapore. (2015). Green mark facilities manager. Retrieved from https://www.bca.gov.sg/GreenMark/gm_manager.html

Building and Construction Authority of Singapore. (2017). About BCA Green Mark scheme. Retrieved from https://www.bca.gov.sg/GreenMark/green_mark_buildings.html

Collins, D., & Junghans, A. (2015). Sustainable facilities management and green leasing: The company strategic approach. *Procedia Economics and Finance, 21*, 128–136.

Darko, A., Chan, A. P., Owusu-Manu, D.-G., & Ameyaw, E. E. (2017). Drivers for implementing green building technologies: An international survey of experts. *Journal of Cleaner Production, 145*, 386–394.

Elmualim, A., Shockley, D., Valle, R., Ludlow, G., & Shah, S. (2010). Barriers and commitment of facilities management profession to the sustainability agenda. *Building and Environment, 45*(1), 58–64.

Environmental Protection Agency (EPA). (2017). Design Guidelines for Green Roofs. Retrieved from https://www.epa.gov/region8/design-guidelines-green-roofs

Harpe, S. E. (2015). How to analyze Likert and other rating scale data. *Currents in Pharmacy Teaching and Learning, 7*(6), 836–850.

Hodges, C. P. (2005). A facility manager's approach to sustainability. *Journal of Facilities Management, 3*(4), 312–324.

Hsieh, H.-F., & Shannon, S. E. (2005). Three approaches to qualitative content analysis. *Qualitative health research, 15*(9), 1277–1288.

IFMA (International Facility Management Association). (2017a). Sustainability Facility Professionals. Retrieved from http://www.ifma.org/professional-development/credentials/sustainability-facility-professional-sfp

IFMA (International Facility Management Association). (2017b). What is facility management. Retrieved from https://www.ifma.org/about/what-is-facility-management

Ikediashi, D. I., Ogunlana, S. O., Oladokun, M. G., & Adewuyi, T. (2012). Assessing the level of commitment and barriers to sustainable facilities management practice: A case of Nigeria. *International Journal of Sustainable Built Environment, 1*(2), 167–176.

International Labour Organization (ILO). (2011). Skills and occupational needs in green building. Retrieved from http://ilo.org/skills/pubs/WCMS_166822/lang--en/index.htm

Kalsoom, Q., & Khanam, A. (2017). Inquiry into Sustainability Issues by Preservice Teachers: A Pedagogy to Enhance Sustainability Consciousness. *Journal of Cleaner Production, 164*(15), 11.

Kats, G. (2003). *Green building costs and financial benefits*: Massachusetts Technology Collaborative Boston, MA.

Klufallah, M. M., Nuruddin, M. F., Khamidi, M. F., & Jamaludin, N. (2014). *Assessment of Carbon Emission Reduction for Buildings Projects in Malaysia-A Comparative Analysis*. Paper presented at the E3S Web of Conferences.

Lee, D. K., In, J., & Lee, S. (2015). Standard deviation and standard error of the mean. *Korean journal of anesthesiology, 68*(3), 220–223.

Michelsen, C. C., & Madlener, R. (2017). Homeowner satisfaction with low-carbon heating technologies. *Journal of Cleaner Production, 141*, 1286–1292.

Miller, N., Pogue, D., Gough, Q., & Davis, S. (2009). Green buildings and productivity. *Journal of Sustainable Real Estate, 1*(1), 65–89.

Min, Z., Morgenstern, P., & Marjanovic-Halburd, L. (2016). Facilities management added value in closing the energy performance gap. *International Journal of Sustainable Built Environment, 5*(2), 197–209. doi:http://dx.doi.org/10.1016/j.ijsbe.2016.06.004

Mohammad, I. S., Zainol, N. N., Abdullah, S., Woon, N. B., & Ramli, N. A. (2014). Critical factors that lead to green building operations and maintenance problems in Malaysia. *Theoretical and Empirical Researches in Urban Management, 9*(2), 68.

National Centre for Vocational Education Research. (2013). Glossary of VET. Retrieved from http://www.voced.edu.au/glossary-vet

National Environment Agency. (2013). Sustainability Management Programme for Public Sector's Facilities Managers of Small Buildings.
Whole Building Design Guide Sustainable Committee. (2016). Optimize Operational and Maintenance Practices. Retrieved from https://www.wbdg.org/design-objectives/sustainable/optimize-operational-maintenance-practices
Workforce Development Agency. (2015). Funding for individuals. Retrieved from http://www.ssg-wsg.gov.sg/individuals.html?_ga=1.49474534.1721970341.1491401830