Jurnal Teknologi

Full Paper

FACILITY MANAGEMENT VARIABLES THAT INFLUENCE SUSTAINABILITY OF BUILDING FACILITIES

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Article history
Received
6 April 2015
Received in revised form
12 August 2015
Accepted
23 August 2015

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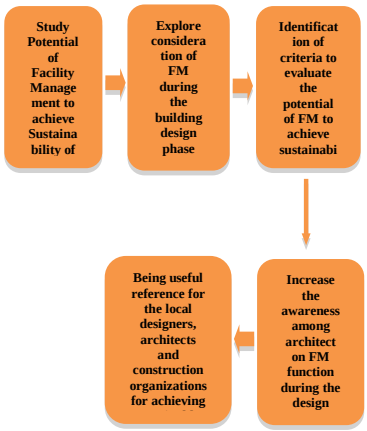
Graphical abstract



Abstract

Incorporating facility management (FM) knowledge in the building design is essential to increase overall performance of building including quality and cost as; the management and operation process of facilities can have a significant impact on energy, cost, health and safety, and quality. As a result, a more efficient and sustainable facility will be turn over during the post occupancy stage. Thus, this paper explores the consideration of FM during design stage and its influence on achieving sustainability of building facilities in post occupancy phase, and subsequently identifies a set of criteria to evaluate the potential of FM to achieve sustainability of building facilities. A critical review of the literature has been carried out for the purpose of identifying the said variables. Literature review reveals that there is a need to review FM potential of the design during the design phase; mainly due to increased life cycle cost, environmental impact, impact on health and safety and quality of the building facilities during the service life. This paper aims to address the long pending quest of poor awareness of the FM function among the designers and forms the basis for achieving FM sustainability of building facilities.

Keywords: Facility management, sustainable building facilities, sustainability, design management

Abstrak

Pengabungan pengetahuan pengurusan kemudahan (FM) dalam reka bentuk bangunan itu adalah penting untuk meningkatkan prestasi keseluruhan bangunan termasuk kualiti dan kos. Ini adalah kerana proses pengurusan dan operasi kemudahan bangunan dapat memberi kesan yang besar ke atas tenaga, kos, kesihatan dan keselamatan, dan kualiti. Akibatnya, kemudahan yang lebih cekap dan mampan dapat diperolehi semasa peringkat pasca penghunian. Oleh itu, kertas ini meneroka pertimbangan FM semasa peringkat reka bentuk dan pengaruhnya ke atas mencapai kemampanan kemudahan bangunan dalam fasa pasca penghunian, dan seterusnya mengenal pasti satu set kriteria untuk menilai potensi FM untuk mencapai kemampanan kemudahan bangunan. Kajian kritikal literatur telah dijalankan untuk tujuan mengenal pasti pemboleh ubah tersebut. Literatur menunjukkan bahawa terdapat keperluan untuk mengkaji potensi FM fasa reka bentuk; terutamanya disebabkan oleh peningkatan kos kitaran hayat, kesan alam sekitar, kesan ke atas kesihatan dan keselamatan dan kualiti kemudahan bangunan sepanjang hayat perkhidmatan. Kertas kerja ini bertujuan untuk menangani kesedaran yang rendah terhadap fungsi FM di kalangan arkitek banguna dan membentuk asas bagi mencapai kemampanan FM kemudahan bangunan.

Kata kunci: Pengurusan kemudahan bangunan, kelesatarian kemudahan bangunan, lestari, pengurusan reka bentuk

1.0 INTRODUCTION

In recent years, the world is focusing on sustainability agenda of built environment consequent from an increasing level of detrimental impact on sustainability (environmental, social and economic) related issues. The sustainability related impact has been seen as one of the major factors contributing to various problems facing by the building industry as the ongoing everyday activities of the buildings account for high rate of energy consumption, cost and social related problems. This has engendered the need for developing sustainable building as the management and operation process of facilities within buildings can have a significant impact on issues related to energy, cost, health and safety and quality. However, several emphasized the need for incorporating FM knowledge in design process to attain the most sustainable solution on the overall performance of a building and its facilities [1-2]. Thus, there is a need to identify the criteria to evaluate the potential of FM to achieve sustainability of building facilities.

During the last decade, researches on sustainability have produced many internationally and nationally recognized methodologies for holistic assessment of building sustainability. However, most of the criteria employed in sustainability process were of technical nature, such as efficient use of energy and resources as well as the reduction of the environmental impacts [3-5]. The nontechnical topics, such as economic and social sustainability aspects were given only little attention although they are so significant issues and need to be considered together with environmental aspects. In addition to that, most of the models take into account only environmental related aspects, and a few authors have given attention to produce a combination of three aspects [4, 6-7]. This paper intends to examine the current literature and aims to identify a set of variables to evaluate the potential of FM to achieve sustainability (environmental, economic and social) of building facilities in the post occupancy stage.

Although the building sustainability agenda has gained importance and captured attention in many developing countries, only a little number of practically applicable research has been conducted in the area of FM related sustainable building facilities. A thorough review on some of the assessment models reveals that there is still lack of consideration of incorporating FM knowledge in the building design stage. Therefore, it is important to consider FM inputs during the design phase of a project in order to achieve sustainable potential of building facilities in post construction phase.

2.0 SIGNIFICANT OF FACILITIES MANAGEMENT IN ACHIEVING SUSTAINABLE BUILDING FACILITES

In recent years, climate change and other rising environmental, social and economic concerns have put sustainable issues on the top of the agenda in almost every city across the world [8-9]. The augmented and urgent sustainability agenda has engendered the need for developing sustainable building, as built environment uses large amount of energy and materials which affect humans health and impact natural environment in negative manners. Housing, office and leisure places lightening, heating and cooling energy consumption is higher than in transport or even industrial sectors. In addition, this consumption continues to increase as well as buildings energy proportion in final emission to environment upturn consumption and CO2 [10]. It is estimated 25% of facilities within a building contributed to global warming [11]. FM is believed to have the potential to be at the forefront of delivering sustainable building and facilities due to the impact it has on the selection, operation and management of buildings [12]. However, Banaitiene *et al*., have argued that it is essential to implement sustainability practice during the building design stage to increase overall performance of building facilities life cycle and attain the most sustainable solution [13].

According to Arditi, design stage is an essential part of the life cycle of a building as most critical decisions are made at this stage. Decisions taken during the design stage influence all decisions made in subsequent stages [14-15]. Therefore, the design phase will form a major source of problem in the post construction phases and that sustainability related FM inputs should be considered at the outset of the project. According to Alhaji & Hassanain, integrating FM inputs with the design will definitely make a greater impact on enhancing sustainability of a building in economic, time, functionality and environmental aspects [2]. In addition, Che-Ani *et al*., has highlighted the importance of considering FM activities during building design whereby the absence of sustainability considerations on FM issues in building design causes various problems in the post-occupancy stage [1]. Che-Ani also outlined the correlation that; higher the quality of sustainability design lower would be the need for maintenance, and lower the quality of sustainable design higher would be the need for maintenance [1].

British Institute of Facilities Management stated that up to 90% of the cost of running, repairing and maintaining a building is determined at the design stage [16]. On the other hand, a study conducted by Al-Shiha, on the effect of faulty design and construction on building maintenance (FM input) found the factors that most affected the maintenance works and caused high maintenance cost including inadequate structural design, hiring unqualified designers, not complying with specification, improper material selection,

inadequate water proofing and drainage, unqualified work force and inability to read the drawings [17]. A survey conducted in Hong Kong on some completed buildings revealed that 40% of maintenance deficiencies were design related, 30% were construction/installation related and the balance 30% of maintenance problems were due to to maintenance management [18]. Developers can save their investment and operation costs if facilities management services are incorporated right into the design phase of a project," [19]. A majority of cost items of the building facilities; including maintenance, systems and resources related problems occurring during the post occupancy stage could probably be reduced by more suitable input during the pre- construction phase [20].

A greater understanding of the driving & restraining forces for sustainability involved within the FM industry is needed in order to create a balance between environmental, social and economic aspects through multiple disciplines activities of FM [21]. Facilities managers have a great role in contributing to the reduction of the built environment impact on the environment as well as aligning their practice with the sustainability agenda along with its three strands, economic, environmental and social [22]. The incorporation of sustainable practices by facility managers into their daily management and maintenance practice have the capability to improve building over long term in terms of the efficiency of its resources consumption and enhanced value consequently it provides a range of social, environmental and financial benefits [23]..

In order to achieve sustainability, building facilities should provide optimal environmental and economic performance, cost reduction and reduce social related problems. From the above discussion, it can be seen that inadequate implementation of FM input at the design stage results in sustainability related problems in building facilities especially during the post occupancy stage. A methodology that seeks to integrate FM inputs with design is highly warranted to improve sustainability of building facilities at post-occupancy stage, as it is lacking in the current literature. It will greatly help achieve sustainability of building facilities during the design stage of a building.

3.0 SUSTAINABILITY FEATURES OF BUILDING FACILITIES

The rising demand and awareness on sustainable building have gained the attention of developers to develop sustainable building and facilities. A good understanding on the sustainable features of building facilities will help identify the FM variables that influence the sustainability of building. A thorough review of literature led to identify the major features of building sustainability (Table 1). These features comprise of environmental, social and economic aspects. Some of the major features of sustainable building facilities are energy efficiency, resource efficiency, cost efficiency, indoor environmental quality, noise abatement, productivity contribution and so on. These features are the indicators which will contribute to sustainability in building facilities. In order to achieve these features, there is a need to identify the variables that relate with FM. The next section of this paper will discuss on FM variables and how it will contribute to achieve sustainable building facilities. The table below illustrates the widespread features of building facilities sustainability as emphasize and proposed by different authors.

4.0 FACILITY MANAGEMENT (FM) RELATED SUSTAINABLE BUILDING FACILITIES VARIABLES

The FM variables related to the concept of sustainable building facilities will help incorporate FM knowledge during the design stage. A proper application of FM principles during the design stage of a project could decrease the environmental impact of buildings through reduced energy consumption, efficient use of resources, improved environmental quality and the life cycle cost which will consequently result in sustainable building facilities. The significant FM factors affecting sustainability of building facilities have been drown from the available literature focusing on causes of problem and building defects occurring during the post occupancy stages. They are Operation and Maintenance [24], Financial [18], Environmental [11], Project Development [25], Facility Planning and Design; Health and Safety [16] and Site Selection or Location [26]. The following section discusses each of the factors and respective variables. In order to achieve the features of sustainable building facilities, the variables that relate with FM need to be incorporating during the design stage of a building.

Table 1 Features of building facilities sustainability

REFERENCES	FEATURES OF BUILDING FACILITIES SUSTAINABILITY												
	Improved Environmental, social and economic impact	Resources Efficiency (electric,water)	Energy Efficiency	Cost Efficiency	Health and Safety	Efficient selection and use of Materials (Economy, Durability, Environment friendly, Recycle)	Indoor Environmental Quality	Efficient Finishes	Noise Abatement	Social and Community benefits	Contribution towards Productivity	Efficient Maintenance and Operation of Facilities	Meet needs and educate occupants (efficiency and conservation)
[27]	*											*	*
[28]	*			*	*	*		*	*	*			
[29]	*	*	*	*	*	*	*	*	*	*	*		
[30]	*	*	*	*		*	*	*					
[31]	*	*	*	*		*	*	*			*		*
[32]	*	*	*				*		*			*	
[33]	*	*		*		*		*	*	*	*		
[34]	*			*			*		*	*	*	*	
[35]	*	*	*	*	*	*	*	*	*	*	*		
[36]		*	*			*		*					`
[37]	*	*	*		*	*	*		*	*			

4.1 Operation and Maintenance (O&M)

Facilities operations and maintenance (O&M) encompasses all the broad spectrums of services that are required in ensuring the built environment perform the functions for which it was designed and constructed. Sapp, defined O&M as the day-to-day activities which is necessary for the building, its systems and equipment to perform their intended functions [38]. Incorporating O&M knowledge early in design phase can help achieve substantial economic, environmental and social benefits which will indirectly lead to sustainable building facilities [13, 39-40].

According to Alhaji & Hassanain, facility manager who is responsible for the O&M activities throughout the operational lifespan of the facility, if integrated with the design team, will definitely contribute to reduce facility maintenance cost and time [2]. Ignorance of this practice in design stage can increase the cost of maintenance [41]. It is estimated that in the USA, up to 50% of the construction budget was spent for repair and maintenance works in buildings [42]. As a consequence the maintenance expenditures could be reduced through integrates O&M activities during design stage.

World Building Design Guide (WBDG) highlighted to optimize the O&M practices, as one of the principles to achieve sustainable building facilities [43]. Since heat; ventilation and air condition (HVAC), electrical and plumbing systems are major building systems that use significant amount of energy, focus on increasing the efficiency of these systems through O&M practices early in design phase, can reduce the energy consumption and lead to energy costs minimization.

According to Chew *et al*., inconsideration on the accessibility requirements of the building during its design stage can cause maintenance problems during the lifetime of the building [44]. There is lack of proper accessibility in most of buildings. In this regards, the attempt to maintain building and its services become costly [45, 41]. The inaccessibility for regular O&M activities was discovered as the common defect for all the building elements [46].

Al-Hammad *et al*., revealed that improper selection of material and finishes causes high maintenance costs in the post-occupational stage of a building [41]. Thus, he proposed that thermal movement of materials, durability and material quality (expired date) should be considered in material selection. Consideration of materiality and durability criteria during design proses will contribute to efficient life cycling process [47].

Overall it can be concluded that O&M optimization, cost minimization, time minimization, accessibility, materiality and durability are among the variables of O&M factor which need to be incorporate during the design stage to achieve sustainable building facility. The key variables attributed to the factor of operation and maintenance factors are summarized as shown in the Table 2 below:

Table 2 Operation and maintenance variables

Operation & Maintenance (O&M) Variables	Authors
O&M Optimization	[43].
Cost Minimization	[2]; [41]; [42].
Time Minimization	[2].
Accessibility	[41]; [44]; [45].
Efficient Material Selection (Environmental Preferable Products)	[41]; [47].
Renewable Material Usage	[41]; [47].
Durability	[41]; [47].

4.2 Financial

Financial is claim as one of the factor of facility management (FM) [18]. Financing is all about creating values. FM's overall objective is to maintain physical assets, avoid disruption on operation, extend the life of the assets and reduce the cost. Facility Management Association of Australia (FMAA) claimed that, forecasting the ability of sustainable projects through financial impact (net present value, internal rate of return, ROI, payback period) in early stage could result in financial sustainability of those projects [48]. Thus it is expected that sustainable building facilities could be achieved through incorporating sustainable financial aspect during the design stage of a building.

British Institute of Facilities Management stated that up to 90% of the cost of running, repairing and maintaining a building should be determined at the design stage [16]. This is because in most of the cases decision made early in design stage can affect the overall life cycle cost of building. There is a need to perform financial forecasting to ensure life cycle cost of the facility and make a reliable planning to minimise the operating cost, maximize the revenue and profit, reduce risks, conserve capital and achieve balance account in the end of statement [49]. Conducting financial forecasting in design stage, will make able to cost effectively maintain a building during the course of its life. These indirectly will lead to sustainable building facilities as the building facilities operate more economically.

It is estimated that, operational and maintenance cost of a facility is the highest cost and it is common for the O&M cost to be ten times more higher than the original construction costs of overall lifespan of the physical assets. Therefore, it is essential to develop FM budget in early stage of a project to understand the needs and level of a management [49]. FMAA stress the need of financial budgeting for facility managers as today they are constantly facing the challenge of delivering services on time and cost effectively [48]. Budgeting can leads to better management of finance by maintaining the cash flow and stabilize the operating cost.

Life cycle analysis is considered as the most significant part of financial aspect of any department including FM. No business has longer life cycle than real estate. Other than being used for design analysis, life cycle process also considered as an important aspect of facility operation. Thus, facility manager has key role in conducting life cycle analysis during the design stage as it will influence reduction in life cycle cost during operation phase [49]. During the design phase Facility manager can provide accurate information on long term operational cost, introduce feasible design for building facilities and guide with construction alternatives in order to achieve sustainable building facilities during the operational phase.

Overall discussion above clearly explains that, incorporating financial variables in the early stage of a project could minimize operating cost, maximize revenue or profit, reduce risks and consequently result in sustainable building facilities. The major financial variables are, forecast financially, budgeting and life cycle analysis. The Table 3 illustrates the summary of key variables related to financial:

Table 3 Financial variables

Financial Variables	Authors
Forecast Financially	[48]; [16[; [49].
Budgeting	[48]; [49].
Financial Life Cycle Analysis	[49].

4.3 Environmental

Environmental has emerged as one of the major issues to be included in building design stage, taking

into account environmental impacts that the building may cause. Several studies have implemented sustainability practice during building design stage as it is essential to increase overall performance of building life cycle and attain the most sustainable solution [13].

There are several environmental impacts that the building construction in general comes to cause. For instance, in term of environmental related issue, building design needs to make more efficient use of materials to minimize the impact on the environment today and in the future [50]. During the process of designing, the building designer needs to consider operational energy consumption and CO emissions, water and waste system, landscape and biodiversity, transportation and the overall environmental performance and sustainability issues as it may cause environment impact during life cycle of a building [51].

William McDonough and Partners, state that indoor quality and comfort could be achieved through reducing the use of fossil fuels during the building designing stage as it produce Greenhouse gas (GHS) emissions [52]. Therefore, a framework which can understand, prioritize and address environmental impacts is vital in order to implement environmental management process during design stage of a building.

Improper selection of building materials by project designer increase maintenance works as well as its budget during the life of a building as most of the designer aim to optimize cost with sacrificing the quality and environmental friendly factors [53]. In order to maintain proper balance between cost, function, and environmental issues facility mangers involvement is needed during the design stage.

Overall it can be concluded that energy consumption and saving, indoor air quality, materiality, solid waste, landscape and biodiversity, sustainable design are among the variables of environmental management factor which need to be incorporate during the design stage to achieve sustainable building facility. The Table 4 below presents a summary of environmental management key variables obtain through review;

Table 4 Environmental variables

Environmental Variables	Authors
Energy Consumption and Saving	[51].
CO Emissions	[51]; [52].
Indoor Air Quality	[52].
Materiality	[51]; [53].
Solid Waste	[51].
Landscape and Biodiversity	[51].
Sustainable Design	[13].

4.4 Project Development

Project management is known as the art of directing and organising social and material resources throughout the life of a project by using modern management techniques to achieve predetermined objectives of cost, time, quality, scope, planning and participation satisfaction. Building is the critical issue in global urbanization which has a tremendous impact on the environment both during construction and operation stage. It is for that reason inevitable that 'sustainability' find its way to project management methodologies and practices in the near future [54]. Even Mackinlay, mentions that the future development of project management profession requires project manager to take responsibility for sustainability [54].

According to Edwards, a project management team need to incorporate energy efficiency, focus on renewable, whole of life considerations, waste management, aesthetics, ecology and biodiversity, land use, cultural and community impacts, materials use criteria into design stage in order to achieve sustainable development [11]. Whereas, in construction phase of a project, proactive environmental management practice, energy efficiency, transport efficiency, sustainable procurement practices, waste minimization and management, health and safety, staff management and development, cultural and community impacts need to be take into account [11]. Furthermore, maintenance staff development and training is much needed factor for a building to achieve effectiveness both during operation and maintenance stage (55). Thus, there is a need to have framework which can address sustainable practices and criteria in the design, construction and operational phases of a project development in order to deliver a project that achieve sustainable outcomes.

It can be concluded that energy efficiency, renewable resources, materiality, waste minimization, transport efficiency, health and safety, cultural and community impact, and aesthetics are variables attributed to the project management factor and need to be incorporate during the design stage to achieve sustainable building facility. The Table 5 below shows summary of project management key variables obtain through review;

Table 5 Project development variables

Project Development Variables	Authors
Energy efficiency	[11].
Renewable resources	[11].
Materiality	[11].
Waste minimization & management	[11].
Transport Efficiency	[11].
Environmental management practice	[54]
Sustainable procurement practices	[54].
Health and safety	[11].
Life Cycle	[11].
Staff Training and Development	[54]; [55]
Aesthetics	[11].
Cultural and Community Impacts	[11].

4.5 Facility Planning and Design

Facilitates planning is concerned with the design, location, layout and accommodation of people, machines and activities of a system or services. Facilities planning include facilities location and facilities design [56]. Facilities location refers to determining how the location of an activity supports the accomplishment of the activity's objective. However, the way the component of an activity support the accomplishment is relay within the realm of facilities design. Therefore, facilities planning and design is the process of selecting the most effectual arrangement of facilities that allows greatest efficiency in the allocation of resources to perform the intended building service.

A good facility planning able to achieve a desired output and quality level at minimum cost. The selection of systems, material, process and equipment's will directly effect the rate of output achieved and amount of capital investment required. According to Balakrishnan *et al*., it was estimated that over $250 billion is spent annually in the United States on facilities planning and re-planning. It is generally agreed that effective facilities planning can reduce material handling cost by 10% to 30% [57]. A study conducted by Dwijayanti *et al*., shows that proper analysis on facility design layout could improve the performance of services by minimizing capital investment cost [58]. Thus, through appropriate facility planning the objective of facility design and location which is to minimize the capital investment of a project could be achieved [59]. One of the aspect whereby building design can be categorized as sustainable is when the building planning and design make great impact on economic aspect. Therefore it is believed, minimize capital investment during facility planning and design can leads to sustainable building facility design.

Thus, an improved and appropriate facility design layout will effectively contribute reduces of idle time and raise the efficiency and utilization of people, equipment and space [58]. Efficient and utilized space, people, equipment and energy planning enables physical resources to be allocated to ensure the building function are properly supported.

A proper facility planning and design will enable the facility manager to assess specific space, respond and complete future maintenance related works on time which will increase useful life of systems and building structure. Therefore, proper planning will lead to reduce operational cost and promote flexibility for future changes and ease of maintenance [58]. Strategically planned facility design will contribute to higher level of productivity as it will provide flexible workspace, allow for quick response and eventually encourage team integration. Flexible facility space planning and ease of maintenance will indirectly promote to improve social and economic aspects of a building facilities through optimize facilities handling process, minimize maintenance cost and increase productivity level.

The major problem of a building design arises especially when designers leaves the details of building projects to unqualified draughtsman [60]. Poor building facility planning and design omissions may result in defective construction. This situation can affect the safety of building occupants. Thus, designer need to ensure facility planning, design layout and material selection are always compliance with facilities planning and design constraints such as building codes and zoning ordinances, fire, health and safety consideration, structural and environmental constraints, utility systems and energy system constraints [59]. Concern on safety standards and codes will promote safety and satisfaction to the building occupants.

Overall, it can be concluded that minimized capital investment, effectively utilize space, energy, and equipment, minimized investment, flexibility and ease of maintenance as well as safety satisfaction are the major variables drown down from the facility planning and design factor. A well-organized facilities planning and design with all the above variables will consequently lead to sustainable building facilities. The key variables initiate under facility planning and design factors has been summarized as shown in the Table 6 below;

Table 6 Facility planning and design variables

Facility Planning and Design Variables	Authors
Minimize Capital Investment	[57]; [58]; [59].
Effectively utilize People, Equipment and Space	[58].
Space Flexibility and Ease of Maintenance	[58].
Safety and Satisfaction	[59]; [60].

4.6 Health and Safety

As declare BIFM, health and safety aspect are attribute to FM factors [16]. Buildings generally need

to consider and provided with safe and healthy environments in order to protecting the health, safety, and welfare of building occupants. However, the potential for health and safety problems such as indoor air quality, occupational illnesses and injuries, exposure to hazardous materials, and accidents always falls on architects, engineers, and facility managers. Thus, architects, facility managers and professionals need to take the responsibility to design and maintain buildings to ensure safety and health of those who will interact with the building throughout its life. Incorporating health and safety aspects in design stage of a building will help achieve sustainable building facility through eliminating hazards, control nuisances and providing healthy built environment [61].

According to Whole Building Design Guide, building design must focus on eliminating or preventing hazards earliest in design stage of a building [62]. This is because, the most effective risk control measure, eliminating the hazard, is often most cost effective and more practical to achieve at the design or planning stage rather than making changes later when the hazards become real risks in the building. Preliminary hazard analyses and design reviews should be conduct to eliminate hazards and provide healthier and safety environment.

A building design should be provide in accordance with good practice as well as applicable building fire, health, and safety codes and regulations in order to prevent faults, malfunction, injuries and illness [62]. Building design is considered safe if it is compliance with legislation. Furthermore, following legislation will promote safety, healthy and hazardous free environment while improve productivity level of occupants and reduce costs of building operation [63]. Thus, standards and recommended practices for installing, operating and distributing energy resources as well as building services systems should be followed by the professionals during the design stage.

The Work Health and Safety Act, require designer, architect and other professionals to undertake, risk assessment and its control methods in the design stage [63]. Often, the design process will occur over various stages and involve different people who make financial, commercial and technical decisions over a design. Such decisions may positively or negatively affect the safety of a building and induce risk. In these circumstances, each party will have responsibility to take duty on minimising the risks associated with the building and work together on appropriate design solutions. It may mean that the facility manager co-operates with designer in changing a design to address health and safety risk and ensure that the rising risks are minimised or eliminated before the following stage.

From the above discussion it is clear that, hazards elimination, legislation compliancy, risk assessment and control are major variables of health and safety. The summary of key variables found under health and safety has been summarized as shown in the Table 7 below:

Table 7 Health and safety variables

Health and Safety Variables	Authors
Hazards Elimination	[62]; [63].
Legislation Compliancy	[62]; [63].
Risk Assessment and Control	[62]; [63].

4.7 Site Selection or Location

Sustainable buildings start with proper site selection as the sustainability of real estate development is determined by its location and the way the site or building is developed. Developers should consider sustainability criteria in choosing a site in order to produce a sustainable building. Choosing a sustainable location has numerous benefits. It creates potential financial benefits to the developer and cost savings by avoiding or minimizing the need to build new infrastructure or doing extensive site grading to the developer and benefits to the owner by restoring health and safety and graded environment, as well as benefits to the society by reducing environmental effects [43].

According to World Building Design Guide (WBDG), location of a building affects a wide range of environmental factors as well as security, accessibility, and energy consumption, local ecosystems, and the use/reuse of existing structures and infrastructures. Energy reduction strategies such as telecommuting, use of public transportation, use of fuel, energy efficient vehicles, and alternative workplace strategies need to be considered during the site selection of a project [64]. Furthermore, Coleman Engineering, has listed topography, vehicle access, site utilities, adjacent property and environmental restriction as the factors that impact the site selection [65].

Therefore, it is important to address sustainable criteria during site selection and the impact it has on the building's overall energy performance to ensure environmental, social and economic issues. Overall it can be concluded that accessibility, security, site utilities, topography, workplace strategies are among the major variables attribute to the site selection factor. The key variables of site selection or location analysis factors have been summarized in the Table 8 below.

Table 8 Site selection or location variables

Site Selection or Location	Authors
Security	[43].
Accessibility	[43].
Energy Consumption	[43]; [64].
Transportation / Vehicle Access	[64]; [65].
Site Utilities or Existing Infrastructures	[43]; [65].
Workplace Strategies	[64].
Topography	[43]; [65].
Adjacent Property	[65].
Environmental Restrictions	[65].

5.0 THE INFLUENCE OF FACILITY MANAGEMENT (FM) FACTORS ON SUSTAINABLE BUILDING FACILITIES

It is widely accepted that if carefully planned, the mitigation strategies for buildings can stimulate the growth of economy, as well as contribute to other, equally pressing, social development such as better housing and access to quality air, energy and water. This has increased the attention of developers and created the awareness to develop sustainable building facilities. In order to develop sustainable building facilities, a good understanding on the features of sustainable building facilities are needed which subsequently will help identify the FM variables that influence sustainability of the building. These features are comprised of environmental, social and economic aspects. As stated before, some of the major features of sustainable building facilities are energy efficiency, resource efficiency, cost efficiency, indoor environmental quality, noise abatement, productivity contribution and so on. The aforesaid discussion revealing the FM variables (factors), have indicated how these variables contribute to achieve sustainability in buildings. Figure 1.0 depicts the relationships between the sustainable features and respective FM variables that influence achievement of sustainability in buildings. For an instance, to achieve the energy efficiency features, the FM factors namely; environmental, and project development factors and each of its sub factors are critical. This is because, through implementing FM factors of environmental, as materiality, indoor air quality, forecast environmental impacts during the building design, it is believed to meet energy efficient features of sustainable building facilities. However, the FM factors of environmental need to be correlated with FM factors of project development during the building design phase in order to significantly influence energy efficiency features of sustainable building facilities.

6.0 CONCLUSION

This article has concludes that implementation of Facility Management knowledge during the design stage of the building development significantly causes achievement of sustainability in building facilities problems during post occupancy stage. This paper has identified a set of FM criteria that influence sustainability in building facilities. Thus, it is expected to solve the long pending quest of poor awareness of functions of FM among the designers and form a basis to promote FM practices to achieve sustainability in building facilities. It will become a useful reference for the local designers, architects and construction organizations for achieving building sustainability through FM. For the future it is important that the existing building stock is addressed to bring down sustainability related problems as majority of buildings in current use will remain for the next 50 years, by carrying their embodied energy and operational energy requirement into the future. Although most of sustainability related improvements are coming from the design community and have the greatest impact on new construction, the existing building stock also should be included in the sustainability arena to the same degree of importance.

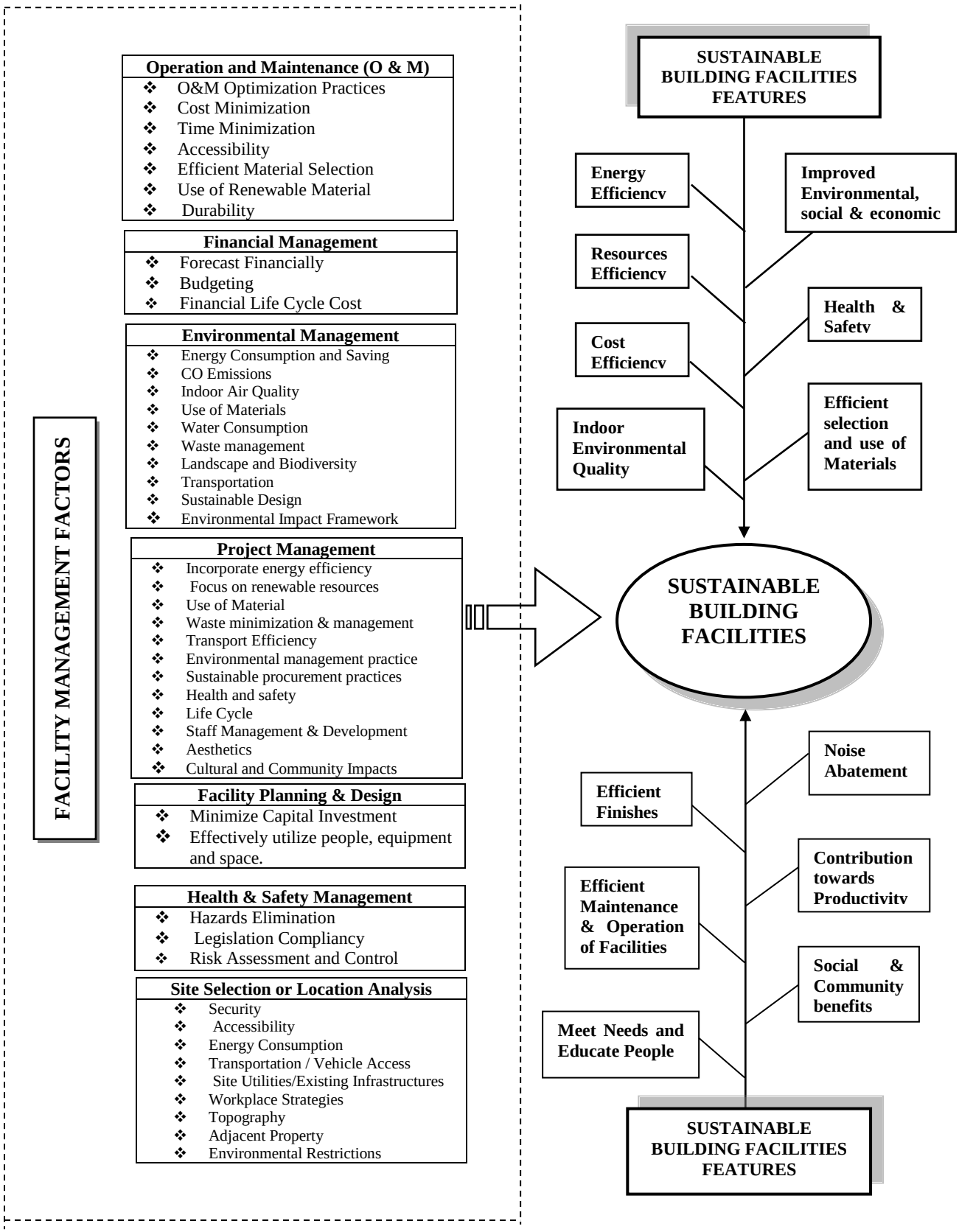


Figure 1.0 Causal relationship of FM factors that influence sustainability of building facilities

Acknowledgement

The authors would like to extend their sincere gratitude to the Centre for Real Estate Studies, University of Technology Malaysia for providing the facilities for research.

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