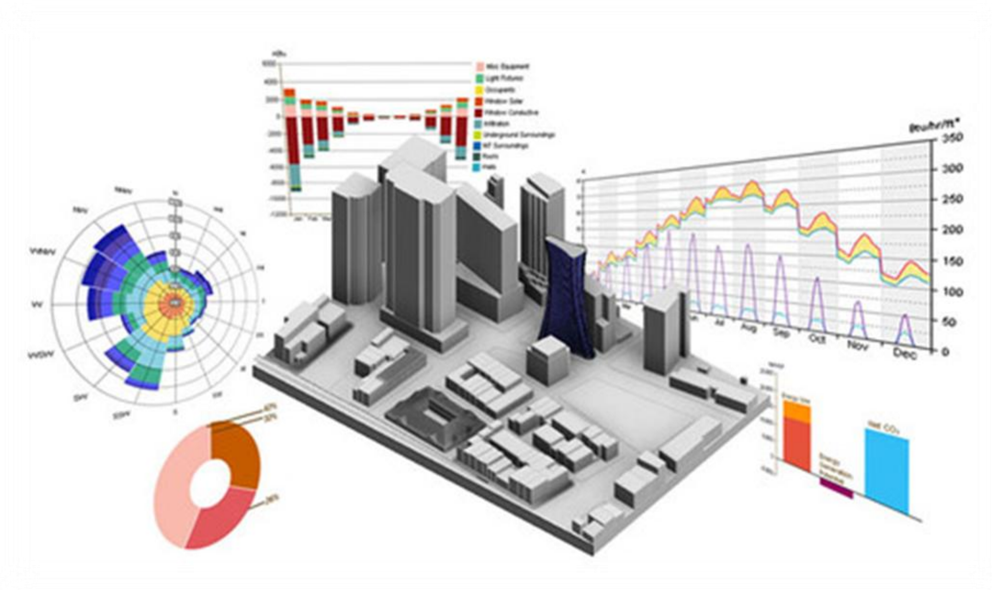
Department of Building, Civil, and Environmental Engineering

ENGR 6991: Project & Report III

Sustainable Facility Management Solutions through BIM



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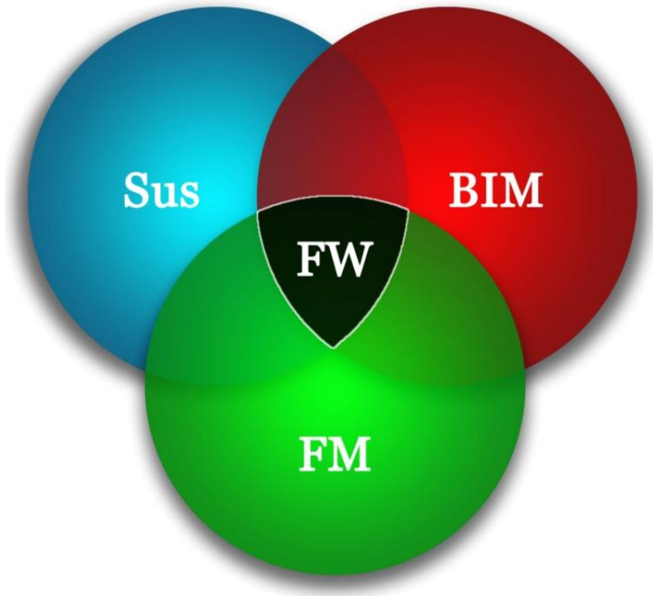
Abstract

Building information modeling (BIM) offers a smart model–based process, which is beneficial to multiple stakeholders including architects, engineers and contractors. While focusing on design and construction, BIM has recently found applications in Operation & Maintenance and Facility Management (FM). Different bodies dealing with construction projects have different definitions of facility management. According to the South African Facilities Management Association (SAFMA), facility management is an enabler of sustainable enterprise performance via the entire life management of productive workplaces and effective business support services.

Facility management is a unique cornerstone in integrating sustainable practices in the management of built environment, and it can be achieved through diverse challenges and conflicting interest experienced.

Adaptation of sustainability solution is one of the major requirements of facility management. Sustainable solutions that ought to be adopted is related to the best practices that focus on organizational knowledge and capability challenges. The BIM-based software and the tools for energy simulation have led to enhanced multidisciplinary collaboration efforts in information sharing, building design and construction techniques. For traditional practices, data are required to be entered manually to facilitate the design. On the other hand, for BIM, the process of entering material data can be omitted for building energy model.

The scope of this report is to create a framework for developing sustainable solutions for the facility management through BIM. This report establishes Framework for developing a new solution that evaluates the sustainability. In this report, analysis literature has been done based on the details of three aspects which are – FM, sustainability and BIM. Qualitative approaches were practiced along with a framework. The next step of the research will be developing solutions of FM.



FW: Framework
FM: Facility Management
BIM: Building Information Modeling
Sus: Sustainability

Figure 1: Framework integration

1. Introduction

Sustainable buildings are necessary considering the impact of the climate change and the increasing global warming which affect the environment. This problem has affected various structures, and it has come to a notation that there is an urgent need to focus on the impact that it brings to both the natural and built environment. The operational phase of the building creates devastating effects on the environment as a result of substantial use of energy and carbon emission contributions. Additionally, the materials used are left on the construction site and become pollutants that pollute the environment and consequently lead to devastating effects of global warming. These calls for the need to consider the property management element of the facility management which has a unique position in the integration of sustainable practices in the management of built environment. Developing the sustainable environment has now become the talk of the day, and it should, therefore, be built without any further time wastage. It is, therefore, a plea to all the architects, engineers and all the stakeholders to embrace a positive change and scale the environment to higher heights. The greatest problem considering the fact to create a sustainable environment to curb the rising global warming effects, attaining sustainability in facility management has been remained as a challenge since the practitioners experience diverse conflicting interests and challenges.

While facility management plays a crucial role in attaining the sustainability of the built environment, there are various challenges to overcome. As identified by British Institute of Facilities Management, lack of skills and knowledge management are the primary barriers to sustainability [20]. It has been identified to be a serious problem among the professionals such as the engineers and the architects. They are said to lack adequate skills and knowledge to address the complex issues that make them even assume their professional responsibilities. It is also observed that, lack awareness and appropriate tools for the achievement of sustainability in facility management, the situation has been worsened by the rising emergence of new tools and equipment. Others factors may be included as the financial, social, physical and historical constraints. These are barriers to sustainability and make it difficult to achieve sustainability under present conditions.

These challenges can, however, be overcome by the use of best practices which focus on the organizational, knowledge and capability challenges experienced. Hence the strategies, learning, responsibilities and roles are the areas that are needed to be developed and come up with best solutions. Building professionalism, skills and knowledge among the professionals is paramount in averting the challenges faced. Use of geographic information system is also a suitable source of information that can be integrated with facility management systems.

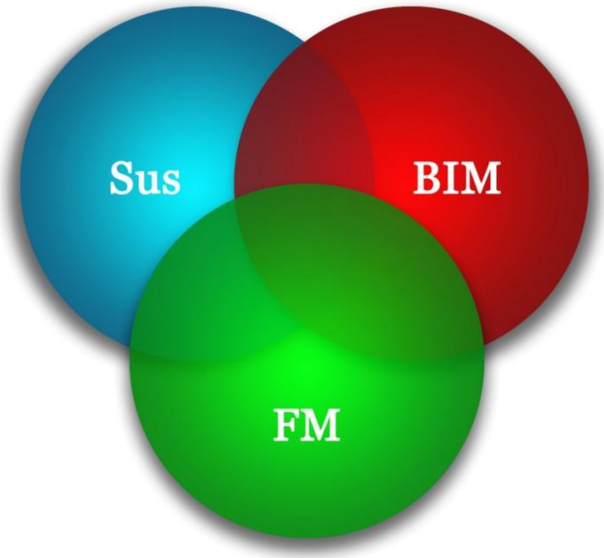


Figure 2: The three Aspects

The scope of the report can be mentioned as three aspects which are- FM, sustainability and BIM. Each of them is important separately, but the more effective way is to integrate all of them together. In each chapter, different aspects will be integrated. At the end, it will be allowed to discuss the framework for developing sustainable facility management solution using Building Information Modeling.

2. Chapter 1: Facility Management & BIM

BIM is an abbreviation for Building information modeling. BIM simplified the means to allow everyone understanding the building. This model is easy for engineers and non-engineers to understand. Using smart 3D model-based process, is suitable required for all types of professionals such as architects, engineers and contractor [1]. The model comes after accumulation of different types of data. The input of the data can be done before and after construction. Moreover, the model can be used after the construction work. The Facility Management (FM) works begin right after the construction. So, it is important to make the model for the project no matter how complex that it is , because BIM output will help people who will be responsible for the building by increasing their efficiency work on the building [2].

FM stands for Facility management. Since facility management takes part in many aspects, there are no specific definitions to describe FM. There are variety of work for the FM that involving many organizations around the world and each one of them has its own view of defining the FM.

The South African Facilities Management Association (SAFMA) defines Facilities Management as “Facilities Management is an enabler of sustainable enterprise performance through the whole life management of productive workplaces and effective business support services" [3].

The British Institute of Facilities Management (BIFM) definition is "Facilities Management is the integration of multi-disciplinary activities within the built environment and the management of their impact upon people and the workplace" [4].

There are some other definitions from different organization. International Facility Management Association (IFMA) defined FM as: "The practice or coordinating the physical workplace with the people and work of the organization; integrates the principles of business administration, architecture and the behavioral and engineering sciences" [5].

Figure 3: FM Functions [6].

2.1 Applications of BIM for FM.

Building information modeling (BIM) tools are technology related applications, that used to generate and manage a wide range of digital representations of both functional and physical attributes of structures, buildings or places [7]. BIM tools represent models that are applied in making decisions pertaining to construction projects. Benefits of BIM tools are depicted by the fact that they can be networked and shared by stakeholders in making decisions for instance about structures. The BIM tools and their models are held within BIM software or applications [8]. These tools are utilized by professionals, government departments and corporations to solve various problems related to designing, planning, constructing, maintaining and operating different structures or physical infrastructure, such as roads, bridges, tunnels, communication utilities, electricity, refuse, water and gas [9].

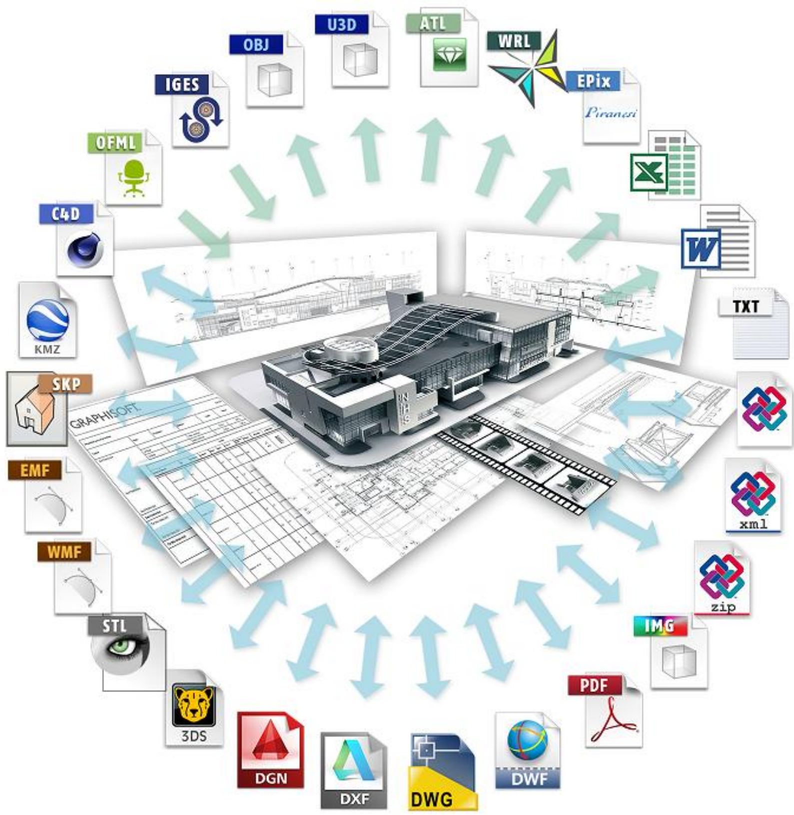


Figure 4: Unlimited BIM file format [10].

BIM tools are used to address challenges associated with implementing construction projects. They are used to ensure that designs and plans of construction projects are aligned with the objectives [11]. Problems faced within the pre-development stage of construction projects, such as cost management, it can also be effectively solved through the application of BIM tools. The management functions of construction projects, such as coordination, supervision, monitoring and evaluation are specifically supported by BIM applications [12]. More importantly, BIM tools are used to ensure that the operations are efficient and coordinated.

The solutions provided by BIM tools are often limited entailed by the proprietary functions of most of the software used. In addition, proprietary formats are often complex to be converted within these tools [13]. This means that BIM solutions may not be aligned with the proprietary requirements for their effective application in facility management [11]. When proprietary information is missing in BIM tools, contractors are likely to face legal challenges. This is because application of BIM tools causes radical changes in relationship between designers and contractors; increasing legal risk for the latter [12]. Traditionally, contractors are not involved actively in design processes. Therefore, they have to rely in facility management on the drawings provided by designers [14]. Notably, in the application of BIM tools, contractors are allowed to sue designers in case there are omissions and errors in provided designs. However, contractors may not able to exercise their legal right since they are required to participate actively in the design processes [15]. Therefore, proprietary challenges may result in problems in the application of BIM solutions, especially when there are omissions and errors in facility designs [16].

The gap between proprietary problems and solutions in the use of BIM tools is associated with the fact that they are relatively new technological applications. This means that not many legal cases have addressed problems related to omissions and errors [14]. This gap is also related to differences in legal obligations of contractors and designers in different jurisdictions. However, several factors may help overcome these challenges. For example, contractors should examine contracts related to BIM projects carefully with a goal of ensuring that they address liabilities and relations. Notably, it is the unique feature of BIM projects that is attributed to the challenges many contractors face [17]. Therefore, proprietary data and legal liabilities should be the main considerations by contractors prior to the application of BIM tools in facility management.

2.2 Information used for Facility Management.

Contractors need adequate data for decision-making enhancing collaboration and efficiency in facility management [16]. The types of information they need to include engineering and architectural drawings, test and balance reports, equipment schedules, monitoring data, design rationale, emergency procedures and maintenance schedules.

FM personal operate is a lot of tasks for the life cycle of entire building such as, preventive the problem happening by planning the right schedule for the items, predictive to repair the items, corrective, respond to trouble calls for maintenance. Not only for maintaining, FM is also, responsible for replacing items that have been used for long time, and the cost of fixing it, if it is higher than brand new one or not. It relates to conduct, test and inspections to maintain, for protecting the build environment.

All tasks of the FM need to work on the principles that have been mentioned previously with required data. Without the data facility manager won't be able to do their job. To do the jobs, FM needs access to large information, several databases, and the location of the information to perform a specific job based on the situation they have.

The FM in this situation is mentioned in the table 1, required specific data to measure the situation. These data gained during M&O of the facilities. Moreover, it can come from management data base, which can be transferred from the model that been generated by BIM.

	Information needed		
FM information systems	**Computerized maintenance management system (CMMS)**	**Electronic document management system (EDMS)**	**Building automation system (BAS)**
Troubleshooting broken equipment	• Open work orders for the equipment, • Work order history, Subcomponent information, and • Test and balance information	• Operation and maintenance manuals, warranty • Start-up reports, • Functional test reports, Location of the equipment, • Occupancy information and schedule, • Design schedule information, • Design narrative briefly describing the system, and • 3D view showing major components and distribution only	• Areas served by the equipment, • Sensor information, verify set points, • Compare design versus start-up versus actual data • Reference points for data for verification, • Sequence of operations, • Network analysis on distribution system, and • Various points for troubleshooting

Table 1: Representing the Potential Information Needs of FM Personnel [18].

Using BIM for getting data has many advantages for the FM such as, effective and direct access to data required for the problem, and this will minimize for both time and labor need for backing up the data. The more labor we used the more inefficient decision were made. Using BIM to extract data will save the time and reduce the number of labor need for the job.

Since, using BIM will save time and labor needed also, using BIM graphics will be more effective to select the target object where the problem is, allowing FM to get the data need it for the obstacles or the problem. So, they don't have to go all over the data or call it the traditional ways, by using graphical model that been provided from BIM, it will be much easier and efficient for FM to work with it [18].

The main challenge that most FMs face is mismatch between content, structures and formats of these documents so that to come up with consistent decisions [15]. Researcher involving contractors and facility managers FM indicate that they often find documents being inaccurate, poorly structured, incomplete or missing essential data. When essential information is missing from documents, they face a challenge of supporting efficient facility management operations [19]. Problems with engineering and architectural drawings represent the main concerns for contractors and facility managers FM. Reported flaws with engineering and architectural drawings include inappropriate formats and mismatch in the structure of the information they contain. For example, CAD drawings provide layers, structures and graphic information [18]. However, layering, such as the one that supports design-oriented views, may not be aligned with requirements of contractors and owners. Furthermore, irrelevant information or overwhelming quantity of information pertaining to operations challenges facility management.

Issues related to the differences in delivery formats of operation documents are often reported by contractors [8]. This occurs when consultants and suppliers produce information without understanding the information needs of facility managers FM. Notably, gradual structures and formats make it hard to incorporate facility management FM data into integrated information systems [14].

2.3 Solving FM Problems Using BIM

Problems related to the control of construction projects in facility management are effectively addressed with different BIM functions. For example, BIM provides model-based workflow solutions that support the control of workflow and promotes productivity in construction projects [13]. BIM also solves problems related to maintenance as it can be integrated to maintenance management systems. The BIM can be used by facility managers as an electronic manual for effective maintenance and recommissioning processes [15].

Space management is one of the biggest problems faced by facility managers. BIM can be used to overcome this problem as it provides visual models to assess how space could be utilized with more efficiency [13]. Therefore, BIM models facilitate decision-making processes pertaining to the use of limited space in facility management. BIM can also be used to overcome the problems facility managers face in implementing sustainable projects [17]. BIM is an updatable repository of programs and data that advance green goals. In addition, the problems of safety characterizing many construction projects are effectively mitigated through BIM. This is because BIM provides the analysis functions that enable accurate modeling of crowd behavior with a goal of predicting safety risks and enhancing public safety within construction environments [7].

Change management is another notable problem that is faced within facility management. BIM helps facility managers implement successful change projects as it is designed to streamline change management processes. Notably, new software packages of BIM are being developed with a goal of tailoring analysis functions to requirements of building automation systems [18]. For this reason, BIM is a preferred model for addressing emerging problems in facility management. BIM can also be used by facility managers to minimize waste. BIM provide for operational and delivery activities that are designed to strip cost [9]. The inefficiencies that are often associated with projects are also effectively overcome through the use of BIM. This is because most of the BIM models are designed to allow for collaboration and mitigation of duplicate work and discrepancies [19].

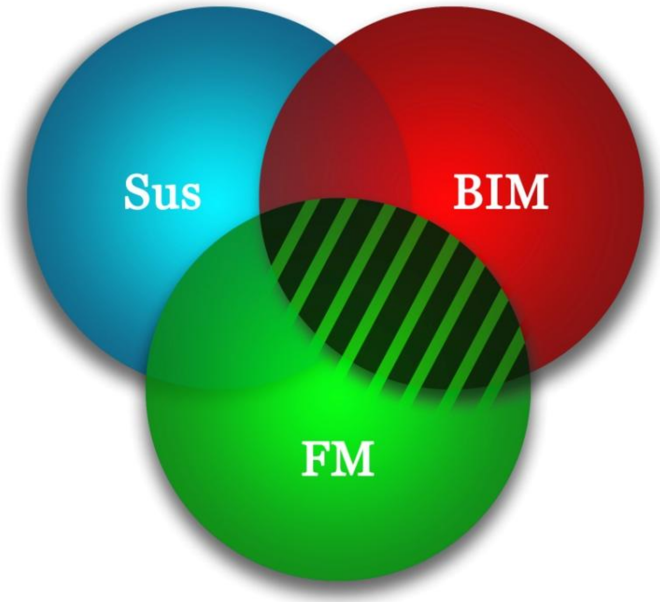


Figure 5: integration of FM & BIM

As shown in figure 5, the three aspects that have been highlighted for the integration that has been discussed at the end of chapter 1. This part has been discussed the application of BIM that FM can use. Also, what is the information FM needs to do their job. Moreover, discussion between the application and the information was obtained in this part that illustrates solving FM problems using BIM.

3. Chapter 2: FM & Sustainability

With climate change and unabated global warming, there is growing focus on the impact of the built environment and the natural environment. For constructing a building there are many phases have affect on the environment. The operational phase of buildings creates detrimental effects on the environment due to substantial energy usage and contributions to carbon emissions. For this reason, the property management element of facility management (FM) has a unique position to integrate sustainable practices in the management of the built environment. However, achieving sustainability in FM remains a challenge because practitioners face diverse challenges and conflicting interests.

3.1 Challenges to find Sustainable Solution for FM

While the practice of facility management plays a crucial role in attaining sustainability, facility manager often face various challenges. The British Institute of Facilities Management (BIFM) identifies knowledge management and lack of skills as the primary barriers to sustainability [20]. Researcher agreed that FM suffers a serious challenge related to the lack of technical knowledge and expertise. This is especially a problem in many cases as other professionals such as engineers often take the responsibility of FM manager. These professionals do not have the required skills and knowledge of the facility manager [21]. Ideally, facility managers must have knowledge to deal with complex issues and assume high levels of professional responsibility.

Moreover, the scope of facility management responsibilities is obscure as it entails competence in performing various tasks.

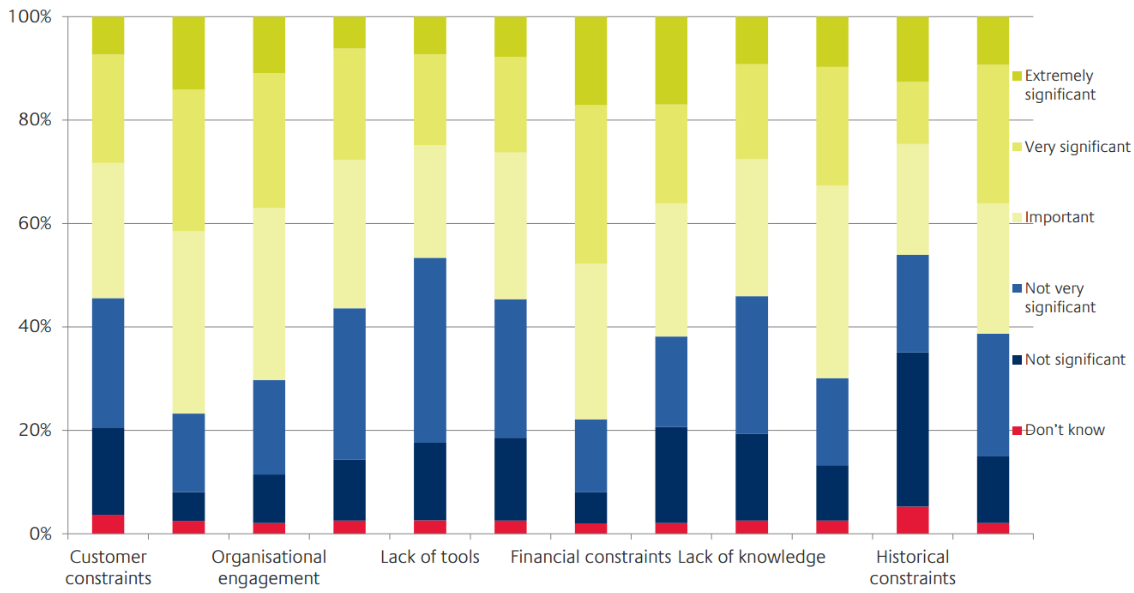


Figure 6: How significant are the following influences the organization? [20].

Facility management focuses on two primary areas that help to make sure that the built environment is functioning efficiently and effectively. Firstly, it encompasses space and infrastructure. Secondly, it covers people and organization. Facility management coordinates the people, and work of the organization [22]. Over the years, the practice has grown to become an essential component in achieving sustainability. However, facility manager face challenges which mainly including lack of skills and knowledge for the management. Lacks of technical knowledge and the expertise required are the major obstacle to the practice.

No	Challenges	Description
1	**Capability challenges**	• Lack of personal capabilities/skills • Lack of professional capabilities / skills • Lack of awareness on building whole life value • Lack of competence in managing the people / institutions' attitude to changing process • Diversity of facilities management roles
2	**Knowledge challenges**	• Lack of knowledge on sustainability endeavours in the FM sector • Limited knowledge regarding key elements of sustainable development (environmental, social and economic) • Limited knowledge regarding legislation related to sustainability • Lack of effort in managing the sustainability knowledge
3	**Organizational challenges**	• Lack of senior management commitment to sustainability • Time constraints on implementing sustainability efforts • Lack of incentives to create a routine for tackling environment issues • Unwillingness to implement sustainability • Limited resources to implement sustainability • Increasing liability of FM organizations • Lack of financial support • Undervaluation of FM contribution to organization success • Limited data on local consumption of energy, water, etc • No sustainability performance indicators during operations phase • Lack of guidance documents • No sustainability policy in the FM organization

Table 2: Challenges in integrating [23].

The challenges faced in facility management and sustainability sub-divide into three categories. First, are capability problems, where the person responsible lacks the skills and technical knowledge needed. In this case, the facility manager does not possess the professional capacity and competence to carry out the tasks at hand [22]. Additionally, the manager lacks awareness on building for the whole life value. Second, are the challenges about knowledge. In this case, the facility manager is not well informed on sustainability measures. Third, are organizational issues. Sometimes organizations do not have people in the senior management who are willing to commit to sustainability. They are unwilling for implementation sustainability measure because of lack of incentive or due to lack of resources. The organization might not have financial backing needs, or the data require or lack guidance documents. Other times it may be that there is no sustainability policy to begin with because the organization undermines the contribution of facility management to its success. Also, time may be a constraint as well as the lack of performance indicators. Historical and physical factors may also create obstacles towards achieving sustainability. Other challenges that facility manager has to deal with are the changing compliance and regulatory standards [24]. The manager must also make sure that the staff is well informed and trained. Security management is also another hurdle for facility managers. They must always ensure emergency preparedness includes setting up evacuation procedures and training all staff. Additionally, they need to have a proper disaster recovery plan in place and act fast when there is a breach of security. Infrastructure takes up a lot of energy which causes inefficiency. Therefore, a facility manager should know how to be energy efficient and maintain for aging infrastructure [24]. Technology in construction and engineering is ever changing prorces, and such managers must keep abreast with the changes.

In my opinion, facility managers have a lot to juggle. From ensuring the facility and the grounds are safe and comply with state regulations to managing the people and keeping in line with set budgets, the managers have a lot to handle. Given the numerous responsibilities they have, facility managers need all the help they can get. They can use Software that helps in reporting, asset tracking, and invoicing, issuing work orders and for storing documents. A sustainable solution to facility management is dealing with the challenges they face as mentioned above. First and foremost the facility managers must possess the knowledge and skills needed to handle the tasks. Then the organization must provide adequate support for the practice.

3.2 Best Practices to Sustainable Solutions for FM

As the field of FM matures and the demand for sustainable solutions increases, it is important to identify best practices. Ideally, the best practices should focus on the three categories of challenges identified that is, capability, knowledge, and organizational challenges issues [23]. To improve the capabilities to implement sustainability in FM, studies identify four key areas of capability that need further development: learning, roles, responsibilities, and strategies. Improving these capabilities would ensure that idea pertinent to ecology, sustainability, and social justice become integral to management priorities [23] [25].

Secondly, FM practice can have benefit from embracing the concept of people capability, an idea that professional facility managers should have the knowledge and skills to improve sustainability practices [25]. Accordingly, the primary components for enhancing people capabilities in implementing sustainable FM fall into five categories: interpersonal capabilities, system thinking, anticipatory, normative, and strategic capabilities [26]. There are consistent with the view that successful sustainability in FM should entail integration of people, place, process, and technology using a life cycle approach to facilities [25]. In the core competencies for sustainable FM span a wide range of areas including technical business, behavioral, and enterprise knowledge. In particular, it highlights eleven core competence areas: quality, real estate, technology, communication, emergence preparedness and business continuity, environmental stewardship, human factors, operations and maintenance, project management, finance and business, as well as leadership and strategy [26].

Thirdly, embracing the notion of stakeholder involvement and engagement can improve FM practice [27] [28]. In the context of FM, stakeholders refer to any individuals or groups who can affect or be affected by facilities and their sustainability efforts. The idea of stakeholder management is to drive strategic direction with opportunities for realizing the continuous learning, innovation and enhancement of the performance [29].

Fourthly, to address organization challenges that hinder the integration of sustainability in FM, it is important to emphasize on the commitment of top management in overall involvement in FM activities. Ikediashi and his partners found that Top management is a key driver for effective FM practices because it has the ability to accelerate the changing environment and improve sustainability.

Elmualim argue that legislation is the most significant driver for implementing sustainability in FM practices [30]. Moreover, the emphasize on lack of relevant laws and regulation as a challenge. The idea is that legislation will force organizations to comply with strict standards and consequently drive the uptake and practice of sustainability. This includes tightening legislation on permitted carbon emission levels and energy management [31]. According to the BIFM, facility managers believe that legislation helps them engage their management board and affords the opportunity to discuss sustainability issues with senior managers [32].

Other drivers and best practices in sustainable practices in FM include pressure from shareholders and clients, life cycle cost reduction, as well as organizational image ethos and corporate image [30]. At the organizational, the best practices for implementing sustainability require committed team work, creative solutions, solid strategies, and measurable goals [33].

3.3 Information Needs for the Solutions

Effective implementation of sustainability in FM requires data and information on a broad range of sustainability subject areas [33]. Indeed, information about sustainability in FM practices can help to improve sustainability. For instance, information on the energy performance of facilities can help facility managers to make effective decisions.

The main information needs of sustainability solutions in the context of facility management include details of long-term measures that are necessary to achieve sustainability such as key Performance Indicators (KPI) [33]. More importantly, information and training are essential components in FM profession. The key information has been classified by researcher into four categories: design information, tender information, construction information, and facility management information. Facility managers need information about the business data, best practices, and other forms of information to have the right decision-making for the facility.

Construction information includes information about the progress of payment, status of construction programs, and supplier list. Lastly, information related to facility management includes details of handling over, defects, maintenance work, and structural warranties. The information required by facility managers varies from one context to another but entails enormous amount of data or information transfer [34]. Therefore, a holistic approach to sustainability in FM encompasses seamless transfer of information among stakeholders through the entire project lifecycle.

Engaging facility managers from the early stages of construction would help to reduce the need for major repairs and alternations that come up later. Building Information Modeling (BIM) is a process that creates and manages all information relevant before and after construction [35]. It is a 3D model that integrates the engineers, architects, owners and all the professionals involved in the development. In recent years, facility managers are part of this model where they gather data from the owner, engineer, and architect. The manager needs to acquire information on the background survey the owner performed. It includes information about which type of building the owner desired to construct. The purpose of constructing the building is a first crucial decision which will determine the other influencing factors [35]. After knowing the type of construction, the owner must look for a suitable location that will fully maximize his desires. Then they must have a design checklist based on what they have envisioned. Also, by understanding the initial design plan, a facility manager can determine if each space if fully utilized as envisioned [36]. In the case that they need to make changes, they refer to the designs. The owner must also consider the size of the building they wants to construct and the funds available. Information on vendors, contractors, engineers, architects, interior designers, and all the professionals procured for the construction is significant [35]. Furthermore, while planning the owner must have come across some problems such as site location, climate condition, ecological value, site information and transport infrastructure. Every data relating to these factors is pertinent while managing the facility.

In the next phase of construction, the facility manager must acquire certain information from the architect. A facility manager accounts for 80% of the life cycle cost of a property while an architect accounts for the remaining 20% [36]. An architect balances the design with sustainability, function and overall appeal. It is important for facility managers to understand the architect's plans and if they tries to comply with state regulations, codes, and technical elements. Therefore, they need all designs the architect applied to the property which includes whether they were within budget and the time it took to complete construction. A major factor to also consider is the sustainability of the design applied and if it is environmentally friendly [37]. Lastly, the manager also needs certain data from the engineers involved. Engineers' engagement begins from the planning stage all through until the property is complete and ready to be occupied. The data required from engineers include test reports, warranties, certificates, manuals, and specifications of the property. From the beginning, an engineer carries out tests to ensure a building has the right foundation, technical measurements and compliance with state regulations [37]. They also consider other factors while assessing a construction such as climatic conditions, location, environmental elements for instance gradient of land. Later on, engineers also make sure that the electrical wiring of the building is at par and the design applied is suitable. All this information gathered by the engineers is pertinent to the facility managers especially in keeping abreast with changing state regulations and standards [37].

3.4 Fast Decision of Facility Management

A facility manager is usually the ultimate organizer in implementing sustainability practices. This role requires fast decision-making [38]. Consequently, fast and efficient decision-making requires reliable information access. The development of technologies, especially in the field of information technology, has a major impact on facility management because it affects the access to information and reuse of previous project knowledge and experience [38] [39].

For facility managers, IT enhances intelligence visualization, information sharing, and improved communications. For instance, simulation tools enable timely and improved understanding of environmental impacts associated with buildings while Internet applications and systems such as e-procurement software enhance business relations.

These systems allow faster decision making in the construction process and improves sustainable development. The emerging visualization technologies include 3Dimesnional Modeling and Visualization tools, Intelligence technologies include case-based reasoning and Artificial Intelligence (AI) systems, while communication technologies including Internet technology [34].

3.5 External Information from GIS

Geographic Information Systems (GIS) applications can provide important source of information for visualization because they can integrate with facility management systems [34]. There are six uses of GIS in facility management: real estate and portfolio management, facility and space management, maintenance management, environmental and sustainability management, visualization, and emergency preparedness [40]. Moreover, GIS and Remote Sensing technologies can assist facility managers to detect changes in environmental conditions using various types of information [41]. The information can assist in various areas of FM practice including site selection and improving the physical positioning of construction projects and buildings.

Achieving sustainability goals in facility management remains a challenge due to a combination of factors such as capability challenges, organizational issues, and knowledge factors. To address these challenges the practice of facility management should embrace best practices in the industry as the field matures. Among the available solutions, information technologies such as GIS, Internet applications and AI will play a pivotal role integrating project knowledge and experience for the improvement of sustainability.

At the end of this chapter all three issues have been discussed, FM discussed with BIM (Chapter 1), and in this chapter 2, FM discussed with the third aspect -sustainability. Also, we see the work of FM to develop sustainable solution for different phases of the work and during the discussion with stakeholders. The next chapter will see the integration between BIM and Sustainability, to know how it works, the information required from both aspects, and ways to solve problems.

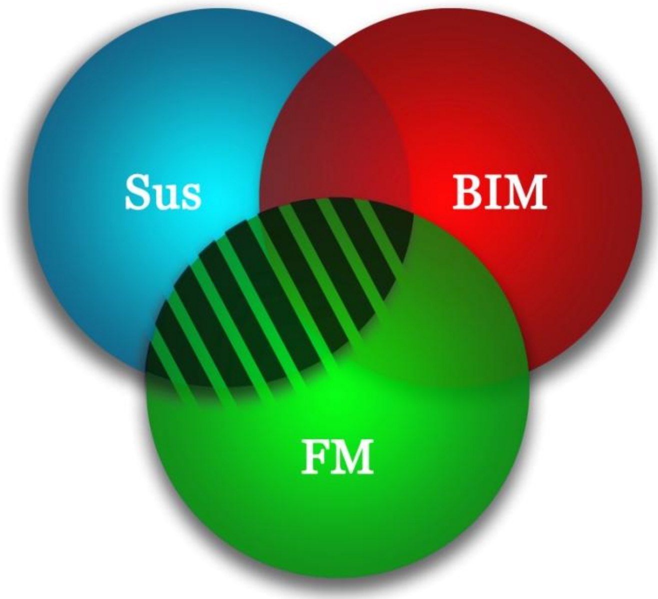


Figure 7: integration of FM & Sustainability

4. Chapter 3: BIM applications for Sustainable practice

There are varied applications of BIM that are aimed at enhancing sustainability at varying stages of the construction and operation of the project. Indeed, it has been acknowledged that the incorporation or utilization of BIM in the course of the design stages allows for more logical decision-making as a result of the enhanced speed, quality, as well as availability of design data [42]. In essence, BIM comes off as a an excellent tool for the attainment of higher triple bottom-line , where economic, social and environmental elements would benefit from increasingly streamlined design process.

First, BIM plays a role in design optimization and integrated project delivery, which reduces the utilization of energy and materials using purpose-built BIM solutions, as well as integrated analysis tools. These tools would be used in evaluating the performance of the building and in choosing solutions that would be effective in the reduction of consumption of resources like materials, water and energy [43]. This would also allow for a reduction of wastage as a result of mistakes and inefficiencies in the process of project delivery.

In addition, IPD (Integrated Project Delivery) might be used in the enhancement of the social sustainability of the construction or building, as it lowers the vulnerability pertaining to a construction project through enhancing collaboration and communication between the members of the team [44]. Indeed, IPD also enhances safety through earlier problem anticipation at the planning phase. Further, the design's quality alongside the construction of built product can be enhanced to offer enhanced living environment.

Moreover, the capacity of the Integrated Project Delivery to enhance collaboration and communication, as well as foster earlier anticipation of any likely problems in the construction process can lower the undesirable wastage [45]. This results from enhanced construction management, applicable in the varied phases or stages of the construction process. The elimination of such wastage, with no doubt, reduces the cost of the project in its entirety. This is complemented by the capacity of BIM to optimize the project design, while still lowering the lifetime and capital costs of the building via enhanced efficiency in the consumption of the energy and material alongside other resources [46].

Similarly, BIM may be integrated with LCA in the building environment, which quantifies environmental effects of building materials on the basis of the LCA technique, while still allowing for comparative analysis of the varying design options [47].

4.1 Information Necessary in BIM

At the heart of the BIM model integration into the construction process is the need to determine the information that would be required or incorporated in the model so as to enhance sustainable design and construction. As such, the information incorporated in the BIM model is obtained from the varied stakeholders including the client and the consultants of the project, as well as laws and regulations of the country or the state within which the project is to be held [43]. So, this underlines the fact that no design or building whose construction is aided by BIM would have the same design, cost or even timeline for construction as the data incorporated in the BIM model would be entirely different.

Current practice of building is dependent on drawings, where building designs would be communicated via numerous distinctive and inconsistent documents. Such models exclude crucial information required for effective assessment and construction of the design. Nevertheless, BIM goes beyond drawings and comes as a data depository for the design and construction, as well as maintenance information for the building blended into convenient model that is shared with every other stakeholder [48]. Such other information would include installation and maintenance guidelines, price lists, timelines, specifications, bill of materials, documents pertaining to bids and contracts, as well as labels and lists of cables [48]. The information would safeguard the making of explicit design information for immediate comprehension and assessment of the design program and intent. Similarly, this would also safeguard on-demand production of varying documents including tables, drawings, as well as 3D renderings, which enhances the capacity of BIM model to contribute more to the improvement of efficiency and provision of enhanced accuracy compared to conventional drawings.

4.2 How BIM Solves Sustainability Problems

The concept of sustainability entails meeting the current day needs while averting the possibility for compromising the capacity for future generations to handle their own needs. The essence of sustainability is predicated on the need for preservation of the environment, provision of healthy environment for individuals, enhancement of durability and efficiency, as well as reduction of the costs of buildings [49]. Buildings would be deemed as sustainable in cases where their design and construction allows for effective performance while lowering the energy requirements, reducing the carbon footprint, consumption of water, and wastage, while still utilizing materials incorporating low environmental impacts. Such buildings would safeguard the wellbeing and health of humans while still conserving the natural environment.

One of the major problems in construction is inefficiency and wastage as a result of miscommunication, redundant reproduction of information [50]. BIM eliminates redundant effort resulting in enhanced communication, with more time being focused on enhancement of design and expedition of the construction.

In addition, BIM optimizes design, which enhances sustainability. It uses green strategies that allow for setting of building orientation for sustainable design. This entails the positioning of buildings on site aligning with the path of sunlight [49]. The interaction between windows and the sunlight affects the building system’s energy efficiency, as well as the occupants comfort. On the same note, purpose-built BIM solutions, as well as integrated tools for analysis may be applied in the evaluation of the performance of the building and the choosing of solutions that would best lower the consumption of resources like water, materials and energy [48]. This comes in handy in the reduction of wastage that results from mistakes and inefficiencies in the process of project delivery.

4.3 Best Practice for sustainable project using BIM

Construction outputs take up a significantly higher proportion of energy, not to mention the impact of economy, as well as the social effects on built environment. Nevertheless, some best practices have been provided in order to optimize effective BIM adoption [50]. Key among them is the need for review of BIM guidelines and standards, as they outline the manner in which BIM can be adopted, as well as how parties to a project can manage the model, and operate within collaborative environments that play a role in the enhancement of social sustainability [43]. Indeed, it is imperative that one incorporates green assessment criteria into BIM guidelines and standards since they are appropriate at the site selection during planning phase, design phase, operations phase, and maintenance stages.

Moreover, an innovative procurement system must be established given that BIM would not be compatible in fragmented environments pertaining to traditional project delivery systems. Indeed, BIM working environment necessitate enhanced multidisciplinary collaboration efforts in the building design, information sharing, construction techniques, as well as strategy for facilities management [50]. An example of innovative procurement systems would be Integrated Project Delivery.

Further, it is important that the entity streamlines the BIM's utilization of demolition, as well as refurbishment elements. This is predicated on the fact that the reutilization of recycle materials, as well as green construction techniques is crucial to the enhancement of sustainability within the built environment [51]. Nevertheless, scholars have acknowledged that BIM offers accurate and speedy estimation of the waste materials during demolition. However, the requirements pertaining of having BIM in the demolition and retrofit stage, coupled with the sustainable techniques or practice pertaining to the utilization of BIM in deconstruction or demolition works have to be specified, as well as streamlined within BIM guidelines and standards so as to foster sustainability efforts [52].

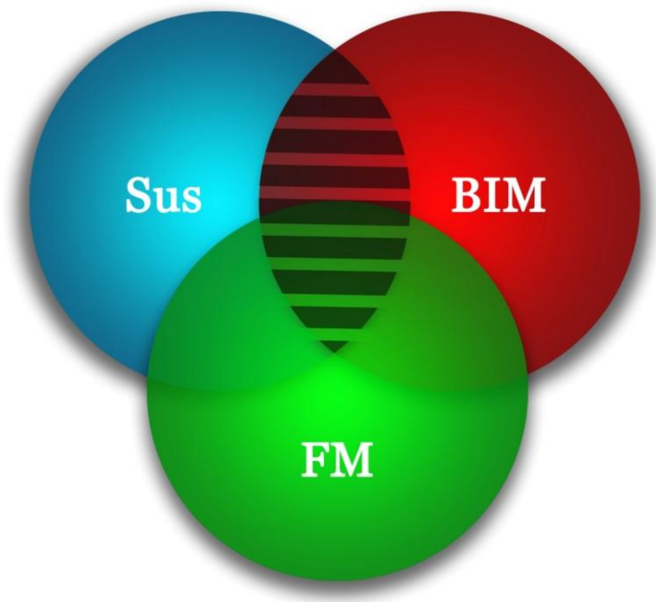


Figure 8: integration of BIM & Sustainability

Lastly, it is imperative that the interoperability between BIM software and the tools for energy simulation is enhanced. Traditional practice necessitates that design data be manually entered to the BEM (building energy model), which could potentially result in the omission of some material data. This necessitates the exchange of design data between energy simulation tool and BIM through the use of data transfer schemas like XML and IFC [53]. The deficiency of energy domain in open-data schemas is problematic as the creation of integrated energy modeling necessitates the resolution of the interoperability issues between energy simulation software and BIM.

Framework

The report analysis literature based on the details of three aspects which are – FM, sustainability, and BIM. The analysis covered the challenges that might face it for each aspect, the information about aspects that are interrelated to each other were integrated in the framework. As well as, mentioning the application of building information modeling for facility management. Moreover, it discusses the best practice and solution of the issues that facility management faces it. The result was evaluated by the Framework. The figures below show the integration for each aspect.

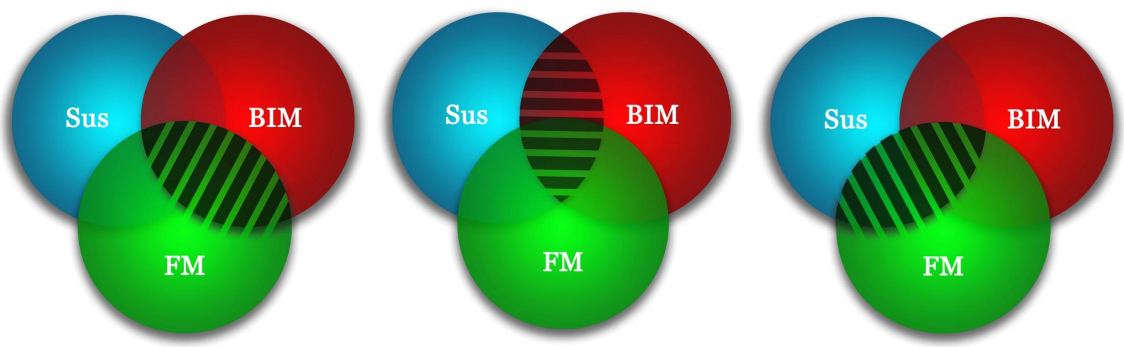


Figure 9: All three aspects

The scope of this report is to create a framework for developing sustainable solutions for the facility management through BIM.

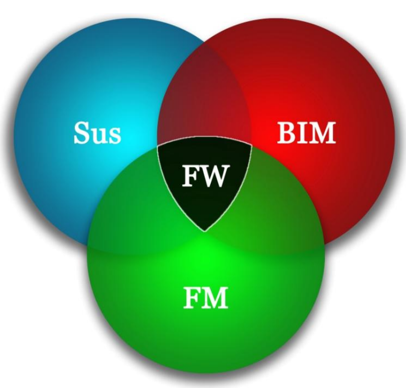


Figure 10: Framework

The table below illustrates the three aspects that are the target of the report, the focus on the Facility management. In the beginning shows Facility managers who want to develop sustainable solutions using BIM. Second, FM's who practices sustainable solutions but are not currently using BIM. Third, other actors who are familiar with BIM, but are not using BIM for FM purposes.

	BIM	Sustainability
FM	✓	×
FM	×	✓
Others	×	×

Table 3: Practicing Part

✓: Know / Use

×: Don't Know / Don't Use

For that, the Framework has been dividing into two tables. The first table is for FM who wants to develop sustainable solutions using BIM. The second, for others who don't have an idea or not using BIM or practicing sustainability.

Facility managers who want to develop sustainable solutions using BIM			
Dimension	**Input**	**Outcome**	**Sources**
1. Requirements	• Best practices • Energy target • Budget	• Social affect • Deconstruction • Economic	• [23,25,30,33,50] • [24,31,43,46,48,53] • [12,19,30,36,37,46,49]
2. Info molding	• Guideline & Standards • Model • Catalog	• Collaboration • O&M scheduling/ optimize • Environment impact • Safety & security	• [31,32,43,48] • [15,16,26,40,48] • [7,23,44,49,51]
3. Long term	• Create an interconnected Network of facility • Speedy • Accurate estimation • Legislations	• Contribute to climate change control • Analysis the facility • Exchange data	• [1,2,14,16,18,19] • [7,42,51,53] • [23,30,31,32,52]

Table 4: Facility managers who want to develop sustainable solutions using BIM

Other actors who are familiar with BIM, but are not using BIM for FM purposes			
Dimension	**Input**	**Outcome**	**Sources**
1. Requirements	• Learning • Roles • Responsibilities • Strategies	• Best Practices • Facilitate Sustainability • Assist Management • Efficiency • Durability	• [23,25,29] • [21,41,49] • [2,13,16,24,46,50]
2. Info molding	• Model changes, Consumption & Reduction	• Energy • Water • Waste • Carbon footprint • Material used	• [23,46,46,48] • [30,31,33,43,49]
3. Long term	• Guideline & Standards • knowledge	• Easy & Faster to follow • Cost effective • Sustainable Operation • Maintenance • Design Change	• [24,31,37,52] • [9,11,14,18,36,37]

Table 5: Other actors who are familiar with BIM, but are not using BIM for FM purposes

Conclusion

It is possible to create sustainable frameworks that can develop solutions for facility management using the building information modeling. In the midst of all the problems, architects, contractors, designers and engineers have the potential and capability to use building information management in coming up with sustainable solutions for the facility management. However, this is possible if the individual players gets involved to take the initiative to embrace the necessary requisite requirement in creating the particularly sustainable facility management. Importantly, the optimization of effective building information management requires the use of best practices so as to achieve higher proportions of energy in construction. It also requires the ability to care about considering the social effects of the construction on the built environment. It is also important to review the BIM guidelines and standards to get to understand the manner in which the adoption of BIM is done and how parties to a project can manage the model and hence operate within the collaborative environments that plays a significant role in enhancing the social sustainability. With the increasing global warming effects in the world, there is the need to adopt sustainable measures that will ensure that the global warming effect is averted. In this regard, incorporation of the green assessment criteria into BIM standards and guidelines in the maintenance, design, planning, and operations phase serves the best in averting the devastating effects of global warming. There also exists the necessity to establish and adopt innovative procurement system for the flaw that BIM is not compatible with fragmented environments that pertain to traditional project delivery systems. As such, it is important to develop a good working environment to emphasize and enhance multidisciplinary collaboration efforts in the strategies for facilities management, information sharing, and building design and construction techniques. The integrated project delivery is one good example of an innovative procurement system.

Since the green construction techniques and utilization of recycling materials are crucial requirements in the enhancement of sustainability within the built environment, it is important to streamline the entity to the BIM's utilization of demolition and refurbishment elements. This is in clear realization of the scholars who have acknowledged that BIM offers a speedy and accurate estimation of the waste materials during the demolition. Despite there has to be the specification of the requirement that implies BIM in the demolition and retrofit stage, coupled with the sustainable techniques or practice pertaining to the utilization of the BIM in deconstruction or demolition works. This helps to streamline the BIM guidelines and standards to foster sustainable efforts. There is the enhancement of interoperability between BIM software and the tools for energy simulation. The omission of some material data can arise due to traditional practice which necessitates the design data through manual entering into the BEM. This allows the exchange of design data between the BIM and energy simulation tool through the use of data transfer schemas such as the IFC and XML. Since the creation of the integrated energy modeling necessitates the resolution of the interoperability issues between energy simulation software and BIM.

Sustainability is very crucial in today world. In the case of building houses and other constructions, it is important to consider the sustainability of that particular concept. The significance of the sustainability prediction is needed to preserve the environment for the future generation and to enhance the efficiency and durability and also to reduce the cost of building as well as creating and providing a healthy environment. To be classified as sustainable, the design of the building and construction must allow effective performance while at the same time decreases the requirements of energy, consumption of water and wastage, reduce carbon footprint yet still utilize materials incorporating low environmental impacts. Such sustainable buildings are suitable in safeguarding the health and the well being of the human beings by conserving the natural environment. It has been found that major problems in construction such as waste, and efficiency are due to redundant reproduction communication and miscommunication. However, use of the BIM helps in eliminating the redundancy hence giving rise to enhanced communication and more time to focus on designing enhancement and expedition of the construction.

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