A holistic vision to achieve sustainability standards using building information modeling technology

Prof. Reda Bahy El-Din Moustafa Youssef
Professor of Interior Design, King Abdulaziz University - Jeddah - Saudi Arabia
rbyoussef@kau.edu.sa
Associ. Prof. Dr. Eman Ibrahim Badr Surkn
Associate professor in interior design
dr.emanbadr@hotmail.com

Abstract:

The research confirms the use of building information modeling in contributing in the achievement of sustainability standards, because with the rise in energy costs and increasing environmental concerns, the principles of sustainability are increasingly being used in the field of interior design and architecture, and it is directed towards providing a minimum environmental impact, and effective decisions are taken to make sure of the presence of standards of sustainability in building elements in the initial design and also in pre-implementation stages. Thus, Building Information Modeling (BIM) can assist complex building performance analysis to ensure a sustainable building design.
The use of Building Information Modeling (BIM) provides multiple means to increase and improve the quality of interior design and architecture projects at the level of design, implementation, facility management, maintenance and operation, and contributes to the accurate preparation and control of schedules, bills of quantities and specifications, and to reduce the total costs of the project. Hence the basic research problemis that there has not been much interest regarding the impact of BIM on achieving sustainability in large projects. Hence, the importance of this research that it aims at supporting sustainable design and construction by evaluating the use of BIM technology in the fields of interior design, architecture and building engineering.
This paper is also interested in exploring the suitability of BIM for sustainability analysis by developing a conceptual framework that shows how an interior designer and architect can use BIM to achieve sustainability and LEED, to create environmental design for all parts of the building. To achieve the objectives of the study, the research uses three research methodologies: Analytical, forward-looking, and critical.
The research is divided into three parts:
-The first part is a theoretical introduction on building information modeling and its importance in the field of interior design and architecture.
-The second part includes the research problem and an analytical study of the elements of sustainability using (BIM) technology.
-The third part includes the research hypothesis that the use of building information modeling technology to achieve sustainability standards and can represent a model for conceptual development.
-The research is concluded by presenting the findings of the research.

Keywords:

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Introduction

The use of Building Information Modeling (BIM) has provided a means to increase and enhance the quality of interior design and architecture projects at the level of design, implementation, facilities management, maintenance and operation, and contributes to the preparation and control of schedules, schedules of quantities and specifications with extreme accuracy, and reduces the total project costs. However, there was little interest in the impact of BIM on achieving sustainability in big projects in the field of architecture and interior design, hence the importance of this research which aims to assess the use of (BIM) technology in the fields of interior design, architecture and building engineering in support of sustainable design and construction.

Whereas, with high energy costs and increased environmental concerns, the use of sustainability principles in the field of interior design and architecture and the provision of minimal environmental impact is increasing, and for this the most effective decisions regarding sustainability in the building components are made in the early design and early implementation stages. In this context, BIM can assist in performing complex building performance analysis to ensure sustainable building design.

The research deals with analytical studies of several green classification systems to explore the relationships between each of them to support sustainable design and construction.

This research is also concerned with exploring the relevance of BIM to sustainability analysis by developing a conceptual framework that demonstrates how an interior and architectural designer can use BIM to analyze sustainability and assess leadership in energy and environmental design (LEED) for all parts of the building.

To achieve the aims of the study, the research uses three research methods. Analytical, forward looking and critical. Therefore, the research is divided into three parts:

- The first part is a theoretical introduction to building information modeling and its importance in the field of interior design and architecture.
- The second part includes the research problem, which is an analytical study of the elements of sustainability using building information modeling technology.
- The third part includes the research hypothesis and uses building information modeling technology to achieve sustainability standards that can serve as a model for conceptual development in the formulation of interior design and architecture.
- The research concludes with a presentation and a drawing the most important results of the research.

The research problem

There is a lack of studies exploring the use of BIM in achieving sustainable design, and therefore the need for this study increases in order to link the trends of modern technical methods for smart technology systems using building information modeling, and the possibility of integrating it with the physical production of interior design and architecture from a sustainable environmental perspective.

Reasons for conducting the search

The general idea of preparing this research came by highlighting what the Building Information Modeling Technology (BIM) represents in the processes of developing a

computer-generated model to simulate the planning, design, construction, and operation of large installations. The building information model is a data-rich digital representation which is directed to all common sectors, as it is intelligent in managing all building's facilities, through which it is possible to extract and analyze the views and data appropriate to the needs of different users.

The research objectives:

Attempting to explore the capabilities and relationships between Building Information Modeling (BIM) technology and sustainable building practices as they relate to space contents and the built-in and external environments through:

1) Verifying the current status of Building Information Modeling (BIM) and its functions in relation to sustainable design practices.

2) Analysis of current trends and future developments of building information modeling technology, and its positive impact on sustainable practices in interior design and architecture.

3) Understanding how to use building information modeling technology to analyze the performance of elements of interior design projects.

4) Determining at what stage in the design development process the use of building information modeling technology is an effective tool in achieving sustainable design.

Research hypothesis:

The research assumes that the use of building information modeling systems (BIM) helps achieve design and implementation dimensions that conventional methods have not been able to reach, especially in large projects that are designed in complex ways and use border design Parametric Design and prefab system technology and by producing machines with technology support with Computer Numerical Control that helps coordinate changes in various building elements and achieve optical integration and interconnection available to all project components. It also supports the use of efficiency to achieve the principles of environmental sustainability, and green buildings by obtaining a leadership’s certificate in energy and environmental design.

The search terms

Building Information Modeling - Sustainability - Fourth Dimension Architecture - Green Architecture - Prefabricated - Algorithms - Border Design.

1) Definition of the term BIM

The term Modeling Information Building appeared at the beginning of 1992 and its use did not spread until Autodesk published an article entitled "Building Information Modeling" in 2002.

The term (BIM) holds many interpretations and definitions. It is an abbreviation for Building Information Modeling, which has, over time, been called Building Information Management. There are different meanings for the same term because BIM applications have evolved over time and that its potential is more comprehensive than the expectation that specialists had initially set. Generally, BIM is defined at two different levels. As follows:

Building information modeling (BIM) is a process in which various specialists work together, exchange information efficiently through data and geometry and collaborate to provide a more efficient building process. The main goal is not only three-dimensional modeling but information that has been developed, managed, and shared, and supported for better cooperation. On the other hand, BIM can be considered as a software platform that allows to coordinate or integrate the work of the various parties responsible for the entire construction, which the interior designer is an important member within this system, as the building information model as a three-dimensional unit (3D) is directed to represent the different dimensions of the building so that the buildings represent a group of "objects" that are related to each other, each element has a unique identifier, and information about the geometry and properties of this element is linked to the rest of the other parts within this system. This method allows for organizing the phenotype and developing various behaviors or interactions according to the type of elements, in addition to these relationships. The building information model allows storing information by converting the elements into data. This enables specialists to easily use each item with its information in the engineering office and the job site. ***(ADEB-VBA - 2015 - p7)***

1 – 1- The concept of BIM systems in the field of interior design projects

The National Building Information Model Standard (NBIMS) has developed the Concept of Building Information Modeling (BIM) as the digital representation of the performance and functional features of all elements and stages of implementation ***(Harris, David - 2007 - p 21).*** Building Information Modeling (B.I.M) is an advanced technology for the use of software in the field of interior design and architecture, as it performs a full three-dimensional digital representation of the building systems completely, and this advanced technology is a precise visual model for the installations and a complete database for recording information with all the design systems associated with the building components.

BIM is far from being a drawing and documentation tool, but rather a platform to enhance cooperation between all multiple disciplines by providing complete information for all systems in an updated and effective way for all elements of the building's internal design and also through the facility's life cycle, BIM has created a major information revolution in the field of architecture, interior design and construction technology, because of its huge potential in providing accurate information in a timely manner not only during the design and construction, but also throughout the life cycle of the building.

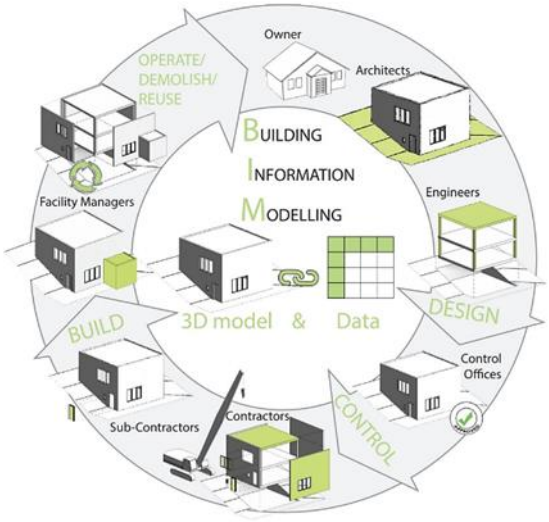


Figure No. (1) building life cycle and responsible parties. (Denis, 2015)

A research study indicated (Azhar et al.). In 2008, the average return on BIM technology ranged from 634% to 1633%, which clearly illustrates the benefits of using economic building information modeling in architecture and interior design.

1-2-Dimensions of using BIM information in the field of interior design and architecture

1-2-1The third dimension (3D) - 3D design and shape and configuration

The Building Information Model is a three-dimensional digital model that represents the building and its intrinsic properties. It consists of smart building components that include data features and algorithm and numerical rules for each component. BIM saves a lot of designer time as each display is coordinated through the intelligence built into the model.

Building the information model is the "digital representation of the physical and functional characteristics of the facility and jointly to obtain information about the facility constitutes a basic basis for decision-making during the building's life cycle." ***(Mehmet - 2011 - p5)***

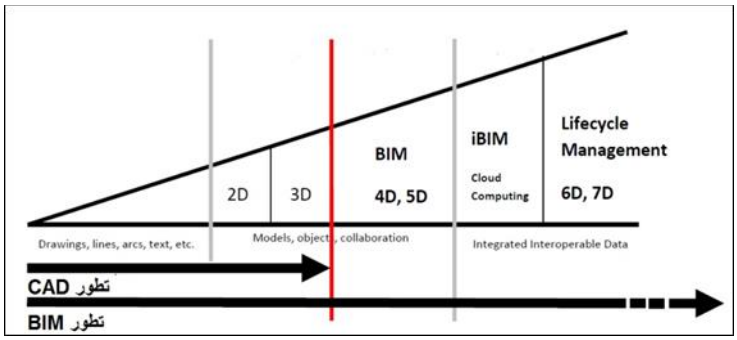


Figure (2) Evolution of BIM Tools and Operations

<u>1-2-2 The fourth dimension (4D) – Time- (3D + time → 4D)</u>

The time dimension represents the fourth dimension in interior design and architecture, as building information modeling helped the ability to prepare schedules for different design projects in a manner consistent with the design and implementation processes, where before that, they depended on achieving this traditionally and separately, which increases the time it takes to complete the task.

1-2-2-1 The importance of using building information modeling in project planning

An important benefit in using BIM in project planning is to better organize the project and provide direct solutions to any conflicts with the movement of mechanisms, workers, and material storage locations. Material and human resources can be combined with the 3D model for better time planning and more accurate costing, and it helps increase productivity and reduce wasting project work by analyzing the progress of work by comparing the basic plan with the actual timeline used, and also helps in communication between project parties by documenting all tasks of the implementation stage and clarifying the mechanism for implementing complex activities and avoiding errors that can occur in the timeline in terms of the logical sequence of tasks ***(Kharbutli - 2014AD - p. 30)***

1-2-2-2 How to link the timeline to BIM technology

The way to make a timeline using BIM technology is done by importing the timeline that is created with a timeline program like Microsoft Project for an analysis tool such as Naviswork and importing the 3D model from one of the design programs used within BIM programs, and when the timeline is linked to the model, we get the simulation time Building elements and the sequence of implementation over time.

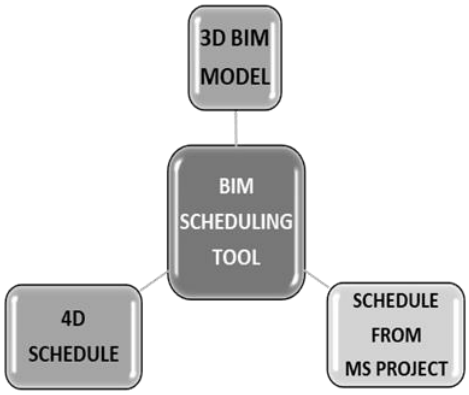


Figure No. (3) Creating a 4D Timeline Model with BIM Technology

1-2-3 The Fifth Dimension (5D) - Cost Estimation – (4D + cost → 5D)

The fifth dimension represents the cost (COST), whereby the use of building information modeling allows the development of a mechanism that helps in calculating quantities according to design specifications in terms of standard specifications for materials and methods of installation and the consequent determination of pricing tables directly at the design and implementation stage.

1-2-3-1 The importance of using (BIM) in calculating (BOQ) and determining project cost

One of the most important applications of building information modeling is BOQ quantities calculation and project cost determination for the ease of visual verification in terms of referring to each element or material within the design, and knowing its quantity accurately as adjustment is made directly to the table of quantities when the model changes as sectors or materials change, as is the advantage of the program Navisworks by providing the advantages of fully calculating project quantities according to the classification of items in a short period

of time accurately, and can make lists of materials, labor and equipment when analyzing prices, and determine their impact on the costs of any item, which helps us in discussing various alternatives with the owner from an economic point of view. ***(Iyad - 2016- p. 10)***

1-2-4 The Sixth Dimension (6D) - Sustainability Criteria

The sixth dimension represents the provision of environmental solutions and effective energy for the design and the building as a whole, where the design model is used in achieving environmental sustainability standards as well as controlling implementation processes in line with environmental sustainability standards with its various controls with the ability to apply adjustments accurately and quickly to the basic model.

5D + sustainability + accessbility → Nd

BIM models have strengthened the task of analyzing and studying energy in front of it, and it became easy to make several models for energy analysis and studies related to energy consumption and provision for a single building such as the lighting study and how to replace lighting and temperature control from cooling and heating, as well as humidity ratios, and research the benefits of vegetation and how to use it to serve, in addition to simulating the wind and sun in ventilation, air conditioning, in addition to simulating weather and climatic conditions throughout the year to determine the comfort zone (Comfort Zone) for the occupants of the building. Sustainability studies also allow the interior designer to know the strategies to be adopted to produce green buildings that are comfortable for the users and that are environmentally friendly, such as the type of materials used, the size of the glass facades, the type and amount of thermal insulation, the amount of holes required for ventilation and the passage of light without heat and how to control them.

1-2-5 The 7th Dimension (7D) - Facility Management Application and Maintenance

The seventh dimension has contributed extensively to the quality of the operation and maintenance aspects of the building and building maintenance (Operation & Maintenance), as it was confirmed that projects that are subjected to building information modeling system are characterized by a significant decrease in the time between the time of issuance of the work order and repair and the operating time of the technicians on site and implementation of the work, gains and other services were also identified. ***(VINCI - 2016 - P4)***

1-2-6 The Eighth Dimension (8D) - Safety and Security

The eighth dimension is a matter of safety and security so that the user is protected from exposure to real safety and health concerns, as BIM contributes to creating 'hot spot' simulation points of accidents and improves users' risks, as with the help of BIM it can greatly improve perception, and manage projects with concurrent programs.

The tools for identifying perceptions of the risks to which the user can be exposed, as well as technicians and those who implement the site design, have four parts:

- The BIM software with its information library.
- The project management software with the resources and planning required for the project.
- The algorithms that use information from the previous two steps.
- User interface ***(John, Godfaurd- 2014 - P8.)***

1-2-6-1 The importance of using (BIM) in the field of security and safety

The importance of building information modeling technology comes in benefiting from pre-implementation discussions, increasing the chances of success of the safety and security plan and exploring prevention options through design, as it is used in simulating different design alternatives. BIM becomes more important when pre-planning security and safety measures, verifying compliance with various standards and communicating with other engineering disciplines involved in the project through simulation and information exchange in the early stages. It also contributes to arranging the general location of the project in a manner that preserves the safety of workers and equipment during the implementation stages, as well as discovering conflicts and studying movement on the site and safe workplaces.

As for the implementation phase, BIM assists in analyzing the methods of implementing the design elements and the risks faced by site workers during the implementation of the design elements, with the need to take into account safe design proposals in order to make design changes or installation of devices on the site and follow up and monitor safety measures on the site in order to reduce unavoidable risks during the design phase. ***(Muhammad Al-Ghattas - 2017 AD - p. 26)***

1-3 The most important challenges facing the application of (BIM) in interior and architectural design

BIM is confirmed that it has become an urgent necessity over time, as it has many and proven benefits in all areas of design, construction and operation, but also there are many challenges that must be paid attention to and taken into account before starting to implement, as the haste to implement the BIM may result in several problems and may lead to abandoning the idea, and thus overlook the many aspects of benefits presented, in exchange for avoiding the dangers caused by rushing adoption by others. There are two challenges:

- First: Adoption decision challenges that aim to answer the question of whether to use a suitable BIM currently? These challenges are affected by corporate strategy and direction, market requirements, and spending capabilities on initial requirements.
- Second: Challenges specific to the implementation process, which are linked to project conditions, staff, outputs, and other technical details.

There is another classification for challenges that depends on the type of challenge, and there is a need for this classification because it is possible to deal with a number of challenges through a unified plan based on this classification, hence its importance for better understanding and the identification of an effective action plan and challenges are divided in terms of type into:

- Technical Challenges, which are related to technologies, tools, infrastructure, codes, and more.
- Social Challenges linked to team, skills, and change management.
- Business Challenges are linked to budgets, associated investments, corporate and organizational insights.
- Legal challenges which are related to regulations - systems - laws - contracts - conditions – codes.
- Operational challenges related to operating mechanisms, expertise, development, and training.

The components of each of these challenges will be presented with its different components in Figure No. (4)

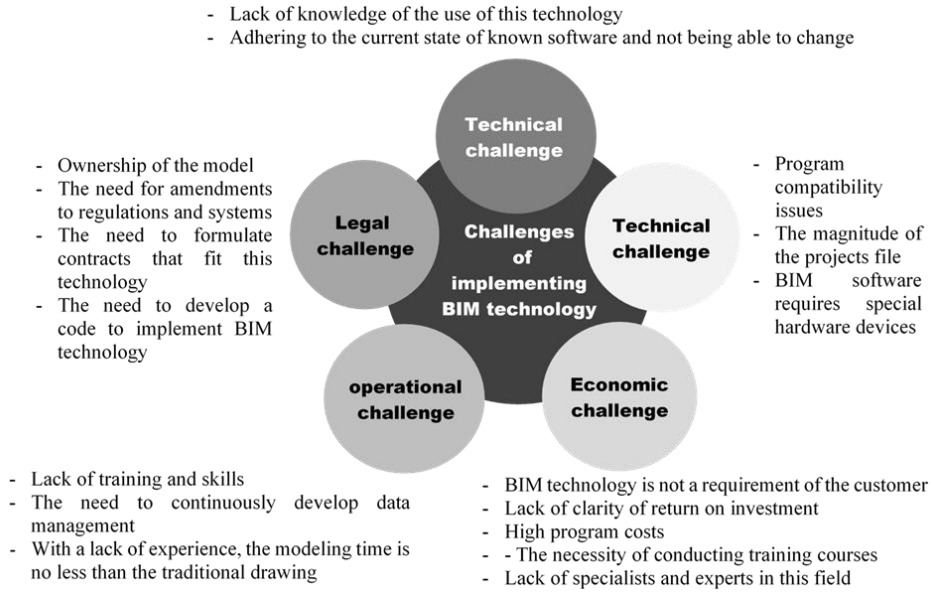


Figure No. (4) Challenges facing the application of BIM technology

2- The stages that the building passes through the design and implementation of building information modeling technology

Interior design processes and other engineering disciplines in the building using BIM building information modeling technology go through three stages BIM - BAM – BOOM.

Where the life cycle of any building is divided into three main stages: design, implementation and maintenance as follows:

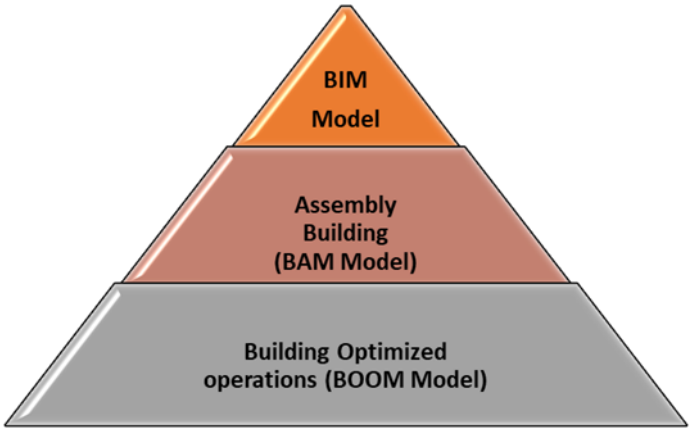


Figure No. (5) stages of design processes using BIM technology

2-1 The first stage

2-1-1 Building Information Modeling (BIM)

It is the first stage in design, in which the form for each specialty is created. This stage represents the application of all design ideas, the use of information to create the model, and providing the form with the information necessary to create it.

2-2 The second stage

2-2-1 Assembly Modeling (BAM Model)

At this stage, different models from all disciplines are collected to study the conflicts that may result from the design. This stage is considered one of the most important stages of the project and one of the main goals upon which the BIM technology is based. The model of the structure moves from the design stage to the implementation phase to act as a tool to provide instructions and directives, where the model represents a virtual simulation of the building even before its implementation, which provides all participants with a clear set of instructions and communication tools among them to master the work and complete it accurately.

Modern trends globally at the present time seek to employ and use prefabricated building mechanisms as much as possible due to their cost and effort and time savings, and to some extent the process of building implementation becomes closer to assembly than to construction.

The assembly information model in this phase allows the management and enhancement of the pre-fabrication process which leads to the conservation of various project resources as well as the high productivity of building elements and components.The benefit of using these systems is evident from the results of a special study in Norway in which the researcher found that 25-30% of the costs of implementation in construction projects are spent as a result of incorrect information exchanged between the work team and the result of weak communication between them, and conflicts are among the costly problems that may occur during the implementation process.

The use of this model, which usually works to regulate the movement and availability of materials and coordinate the tasks of workers and technicians, contributes positively to reducing financial resources and the spent time, also the site manager can prepare the site for what is necessary in the specified time and follows the level of work development by establishing timetables and progress plans in Stereoscopic and re-enacted reenactment as a project control tool, which is essentially the default model for it, and management must only implement it on the ground.

2-2-2 Manufacture and Assembly of Product Elements

Building information modeling technology can manufacture complex non-standard interior design elements such as Parametric border design with standard and special sizes and specifications by supporting Computer Numerical Control (CNC) technology. Assembly Modeling is marked with the items to be manufactured.

Then the machines manufacture the required formations through the specified materials for implementation, and these machines can deal with all types of raw materials as this technology is characterized by its endless ability to manufacture and assemble any design, no matter how sophisticated it is.

2-3 The third stage

2-3-1 Building Optimized Operations Model – BOOM

The employment model for the building is represented in the maintenance and building management phase, and it is the last stage in which building information modeling systems can be employed to sustain the building life and provide its full capabilities to the user.

Through the building's operating model, the building's details can be evaluated. For example, spaces that need to be re-furnished or to fill a deficiency within them can be identified, identifying damaged items that are movable or changeable in the building, such as doors, windows, metal sections, and furniture for the purpose of replacing or restoring through knowing their specifications and date of installation, and also identifying the provider or manufacturer and be able to contact them using the provided form of information, even after a long period of time. The ideal operating model for the building is not only the 3D model, but it also works as a store of documents and data for the building during its life, monitoring technology and an administrative alert for all its parts, and a tool for scheduling maintenance and restoration works that it needs during its occupation period. ***(Kamal Shawky - 2017 AD - p. 24)***

3- BIM Technology in Parametric Design

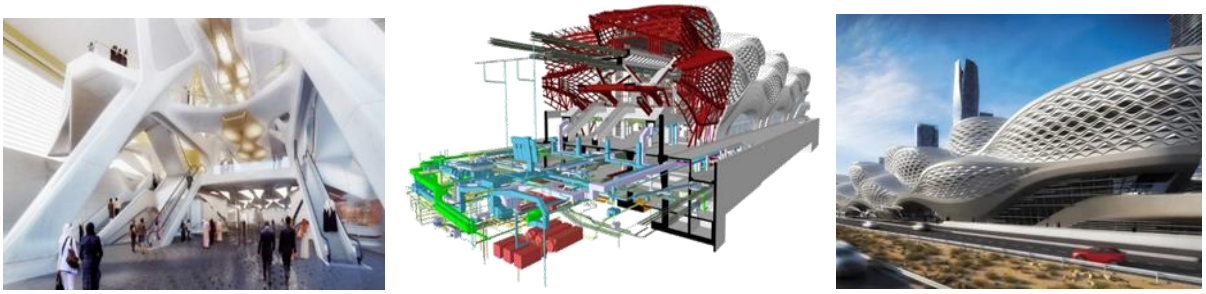
Parametric Design is a semantic visualization that has its mathematical foundations and its basic uses are used in statistics science and digital technology. It analyzes complex systems and formations that require complex calculations using programs, algorithms and computers to process and produce mathematical equations for the purpose of solving articular complexity problems in the design process.

BIM is used in parametric border modeling to create relationships between elements within a complex structure construction model. These relationships include physical and functional characteristics as well as project life cycle information. ***(Azhar - p 11)***

It is also possible to create a three-dimensional model from the data provided by all parties involved in the project, and this model allows them to understand the project clearly using the integrated information of the model, to define their views and needs to update the model through the project life cycle, and to identify and solve construction problems before they occur on the site, especially in projects that have a large amount of complex architectural composition and difficult to implement by traditional methods.

It also supports the use of BIM to solve any clashes that occur due to incompatible graphics and design of various disciplines, which before that were not discovered until the construction stages begin which cause significant delays in the planned timelines and conflicts on site. But these problems are solved by using the building information model, where these clashes can be discovered during the design phase before starting the implementation stages, which helps information extracted from the model in identifying all aspects of the pre-made components to be collected directly on the site. This results in more implementation work that can be performed outside the site, which gives higher efficiency and distribution of works at accurate time rates and completion in a shorter time.

An example of the work done using BIM technology in Parametric in Figure No. (6).



https://www.bimcommunity.com

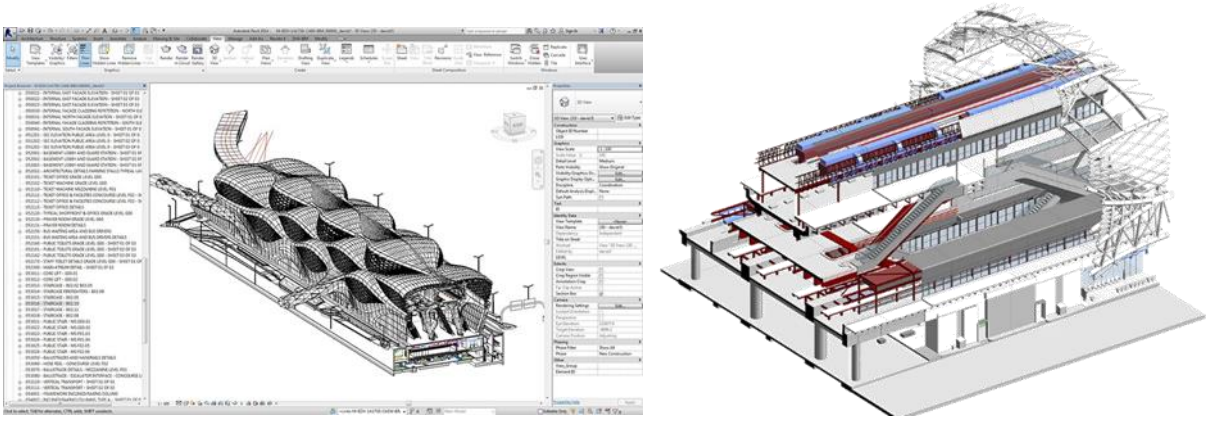
Figure (6). Design of King Abdullah Financial Train Station (KAFD) - an area of 45 thousand square meters in Riyadh, Saudi Arabia, and ZHA has developed its program for planning complex engineering Parametric Design - currently in the construction stages and is scheduled for the project to be completed in 2020.

- Implementation of Zaha Hadid Architects Company.
- This construction was designed and constructed with BIM technology "BIM Tools: Zaha BIM, Maya, Rhino, Revit."

The design includes six platforms on four general floors and two levels for underground parking, and this complex construction is implemented at BIM Level 2 development using Revit - IFC BIM Models, which is compatible with the level of development (LOD 350 - Construction Documentation.)

The building's façade and roof are characterized by a series of winding waves, inspired by the intricate natural patterns in the dunes, and curved mesh screens that simulate the look of ancient Arab art in Mashrabiya. Architects describe it as a "three-dimensional poetic network defined by a series of corresponding waves."

Implementing this Parametric Design is considered an architectural challenge that is difficult to design and implement accurately in Autodesk Revit, due to the complexities of its double curved shapes and the calculation of its multi-sided angles, so ZHA chose to develop its BIM components and adapt to implement this design.



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In Figure (7) the architect's design started in the Maya modeling program, where he was converted to low polygonal networks and imported as a package from CAD, connected to T-Splines surface modeling programs, and ZHA undertook a specially designed program, "Zaha BIM", making necessary changes on the data to create a smooth and accurate engineering can

be displayed in the Revit program to simulate the manufacturing details on the form and all the services and metadata required to be implemented.

There have been great difficulties in developing the design of streamlined bends at the detailed level, and therefore rapid design processes were carried out in the Maya and Rhino programs, and then they were introduced in a BIM-compliant environment, and this development was included in the innovative work developed by ZHA in a research presented at the University Autodesk in London and Los Angeles in 2018 CE by Eckart Schwerdtfeger.

Among the challenges that faced the project is that it took more than a year for the project team to become integrated and familiar with BIM information and the proficiency of how to share information, and this has resulted due to the fact that some of the companies concerned did not deal completely with BIM technology before that.

According to Harry Ibbs reports - *(Harry Ibbs is the director at Gensler Design Technology Studios Former Head DT Zaha Hadid Architects)* - the primary benefit of working in BIM has reduced project risks because providing a fully consistent model in the implementation phase, including mechanical and electrical engineering and structures, has given the client and project supervisor more confidence in construction, the main contractor uses 4D operations - 5D BIM for business sequence planning, and material cost calculation.

4- Sustainability and green buildings

Many organizations have evaluated green buildings to reduce pressure on buildings in the environment and have been created with the aim of analyzing and evaluating interior design projects, existing architecture, and construction performance. The primary mission of these organizations in building evaluation is to promote high performance buildings through design, construction and implementation, and process maintenance practices ***(Cam C., Ong B. 2005 - p15).***

The main roles of green building evaluation institutions are defined as follows:

1. Working to increase awareness of environmental issues in the design and construction sectors and encourage specialists in providing environmentally friendly construction.

2. Setting construction standards that are compatible with the environment to maintain the minimum performance standards, by evaluating the interior and exterior design.

3. Providing a platform for inspiration of new technical designs, ideas, and solutions.

Building information modeling technology is used to provide data to evaluate energy performance and assess sustainability. Leading design organizations are adopting this approach to enable building design, construction, and integrated maintenance of buildings to reduce Net Zero Energy consumption. The green BIM model includes energy modeling in buildings that addresses the design and evaluation of project energy performance to identify options that improve energy efficiency over the life cycle. By allowing reviews during the design phase, parties involved in the project can ensure that customer ambitions towards Green Buildings can be fulfilled, along with technical and economic requirements. Thus, building information modeling technology can provide information to support the achievement of sustainability levels related to accredited international classification systems and LEED certification. ***(Sebastiano, 2016, P1)***

In projects that seek to obtain a Leadership in Energy and Environmental Design certification, you find that the majority of points require the handing over of the plans that support the

acquisition of these points, and although most of these plans can be prepared using traditional CAD programs, building information modeling technology software produces these graphics more efficiently as part of the building information model, and it has the additional advantages of a technological transformation in border data PARAMETRIC DATA, which coordinates changes and maintains consistency at all times, thus the user does not need to update the diagrams or links manually, as these forms carry a tremendous amount of information on many other aspects of sustainable design and LEED certification such as building component schedules, can be obtained directly from the model to determine percentages for material reuse and recycling, and their final value.

In addition, advanced modeling techniques can convince customers that green design is performing well. There are more than twenty standards in LEED and environmental design systems that can be obtained and supported using the Building Information Modeling methodology.

4-1 Principles and Elements of Sustainable Architecture

- Energy Conservation: Through energy efficiency using the lowest possible energy in cooling, heating, and lighting operations.
- Adaptation to climate: where buildings are appropriate to the nature of the environment.
- Reducing resource use. What is meant by modern resources that are harmful to the environment?
- Providing a healthy indoor and outdoor environment through building materials.
- Respecting and protecting the site: To sign buildings on the ground in a manner that do not cause fundamental changes in the features of the site.

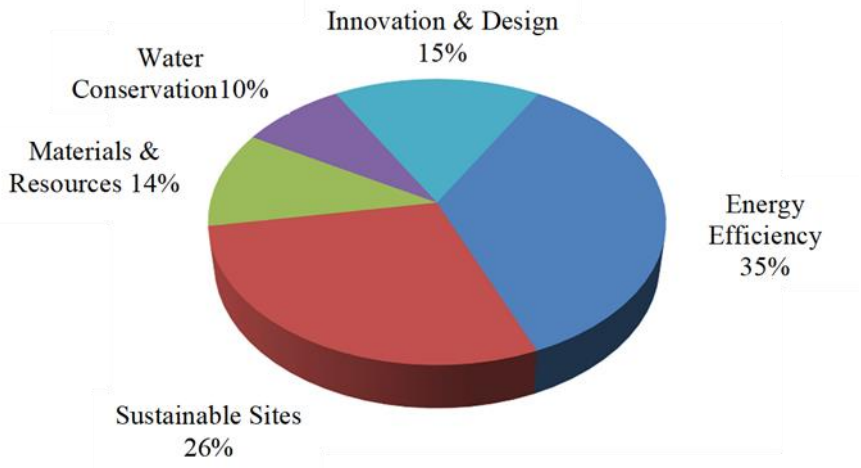

Figure No. (8) distribution ratios of principles governing sustainability requirements in the field of architecture and urbanism.

4-2 Conceptual framework for sustainability analysis using BIM

Intellectual and technological changes in various fields at the present time have changed the design methodology in terms of inventing ideas and mechanisms for developing and implementing them, and many studies carried out by researchers recently confirmed the imperative of reviewing methods of interior design, through the use of digital technologies, to facilitate understanding the design environment and its implications for calculating design variables and their new challenges ***(Mark, B - 2005 - p22).***

Where the use of digital technologies and the huge speeds provided by the programs contributed to opening broad horizons through which the interior designer can achieve everything he wants ***(Kloft, H - 2005 - p138.)***

Through this concept, the use of building information modeling technology enables the designer to create a three-dimensional model and data and information as an integral part of the project through its various phases, from design through implementation to the operation stage, information and data can be combined with the model through simulation of the Physical and technical characteristics of the building, which makes it an effective way to take design decisions, analyze performance, develop design, study viability and achieve sustainability principles ***(Muhammad Al Ghattas - 2017 - p. 21).***

BIM systems work to achieve building support and benefit for all project parties. Figure 10 shows the impact of BIM use on all project parties during the building life cycle as well as the conceptual framework for BIM-based sustainability analysis during the various stages of the project at its three levels (design - implementation - Employment).

Where the direction of the middle arrow in Figure (10) indicates the different stages of the project. The bottom sequence depicts the characteristics of process analysis that are subjected to different sustainability principles, while the upper sequence indicates the interaction of project parties (such as the interior designer and architect, manufacturers, EIT and king) in sustainability analysis. This framework can be used by design and implementation companies that wish to implement BIM-based sustainability.

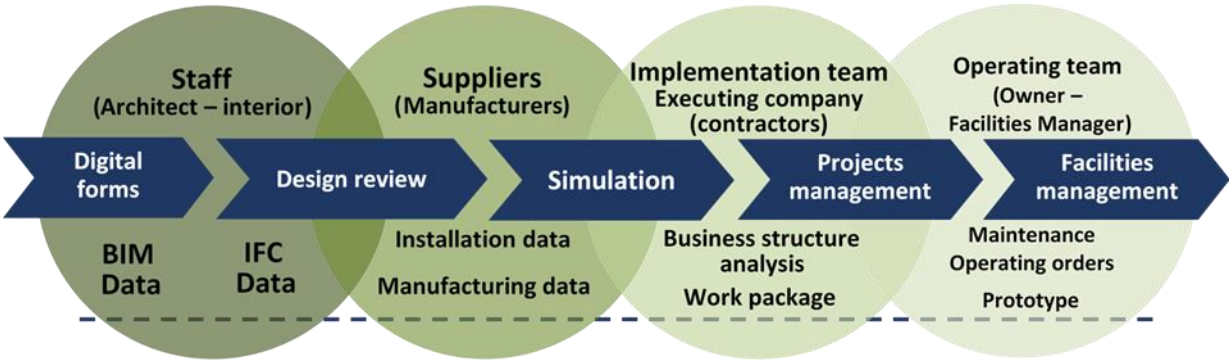

Figure No. (9) The three levels (design - implementation - operation) and achieving BIM during the building life cycle.

Whereas, the BIM construction methodology is based on representing the building as a coordinated integrated database, and this means a clear visualization of the building's shape and providing a lot of data needed to naturally support sustainable design in the various phases of the project.

In addition, integrating BIM construction information with performance analysis tools greatly facilitates complex analysis. This approach gives interior and architectural designers easy access to tools that provide an immediate response to design alternatives early in the design process ***(Eddy Krygiel - 2008 - p 94.)***

In 2008 Nies and Krygiel indicated that BIM can contribute to the following aspects of sustainable design:

- Building Orientation, the optimum orientation that leads to a minimal energy consumption.
- Building block, analysis of the building's shape, and suggesting the best facades.
- Take advantage of natural lighting in the interior design of the spaces.

- Collecting water to reduce the building's needs for water sources.
- Design models to reduce energy consumption and analyze the potential for using renewable energy sources.
- Using sustainable interior design materials and using recycled materials to reduce the exhaustion of natural resources.

5- The Level of Development (LOD)

There are five different levels that were classified by the American Institute of Architects – *(The American Institute of Architects (AIA) is the leading professional membership organization for licensed architects, emerging professionals, and allied partners. Its headquarters is in Washington, DC)* - in a document called the BIM Protocol (E202). These development models are specifically designed for different design stages, 3D visualization, building quantities and specifications, timelines, estimates and costs, production and manufacturing control in Location ***(Dmitri, 2013, P10).***

5-1- LOD 100- Concept design

The 3D construction model was developed to represent information at the basic level and therefore, the concept design concept can only be created at this stage where the elements of the model are graphically represented as symbols and design criteria are defined and also the shape, area, height, size and so on are defined.

5-2- LOD 200- Planning -Schematic Design

General template with minimal detail in which elements are designed with approximate quantities, size, shape, location and direction. Basic modeling takes place through sustainable development.

5-3- LOD 300 -Detailed Design

A general model that adequately determines the components and modeling of accurate drawings and operational diagrams and the model dimensions may be accurate or approximate as the elements are developed according to the methods of installation, quantities, size, shape, location and direction of the design.

5-4- LOD 350 - Construction Documentation

A detailed model illustrates how building elements interfere with each other and with different systems using graphics and includes details of the model how to build design elements and interact with different systems. The model produces some details for the production of executive drawings and other construction elements and being matched with drawings and data.

5-5- LOD 400 - Fabrication & Assembly

The elements of the model are designed in the form of specific installations, laying the foundations and methods of manufacturing and assembling in full and details of the information in addition to counting the quantities according to the standard specifications.

5-6- LOD 500 - Final implementation

The elements are modeled as structural installations for maintenance and operation.

5-7- LOD 600 - Facility Management

An accurate template for the structural elements of the final design of the design, by adding facility management data to the previous model (LOD 500) for maintenance and operation requirements. ***(The Egyptian Code, 2018, P16).***

THE LEVEL OF DEVELOPMENT (LOD)

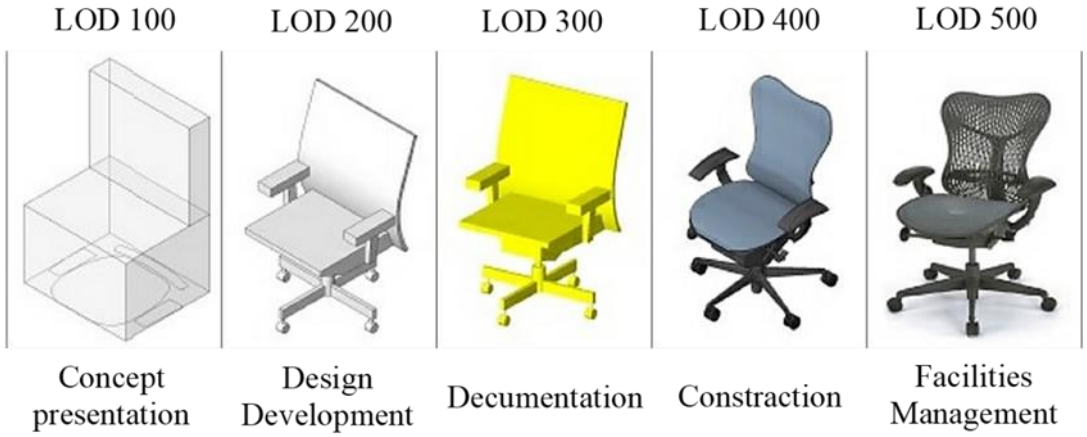

Figure No. (10) A figure showing the development of a three-dimensional construction model for a seat at different levels of development. (https://www.kangleibimsolutions.)

We must look at the model shown in Figure (11) for the level of development (LOD) in producing a seat with a specific design that the requirements move upward, where when each level is fulfilled, the transition is made to the next level so that the basic requirements for the previous level have been fulfilled and that one level has all the levels that precede it.

The following table shows a relationship that linked the different levels of development with the parties involved in the proposed project and the distribution of competencies of everyone within this system.

Table (1) shows how to apply the five forms in the level of development program for building information modeling technology

Contractor	Consultant	Designers	Owner	(LOD)
Provide feedback on the initial implementation cost, schedule, and deliverability	Provide feedback on the primary performance goals and requirements of the design	Design model starts with general concepts and design considerations	Provide requirements regarding form, function, cost, and schedule	**Conceptual Design**
Provide design review and ongoing	Provide schematic modeling,	Refine the design template with	Provide design review and further improved	**LOD 200 – Schematic Design**

feedback on cost, schedule, and implementability	analysis, and iteration patterns within the system while continuing to develop the design	new inputs from the owner, consultant, and executive	design requirements	
Create a model for simulation, coordination, estimates and timeline	Create prototypes and analyze design according to technical specifications	Continuing to refine the design model, introduce consultant models, and implement the modified form	Design reviews and final approval for seat design and measures	**LOD 300 – Detailed Design**
Strengthen the construction model and implement the final evaluation and implementation timetable	Finalize designs, implementation documents and specifications, and comply with approved design requirements	Finalize the design template, implementation documents and specifications, and comply with regulations	---	**LOD 350 – Construction Documentation**
Manage implementation with workers and suppliers, and report changes to the design model	Responding to implementation and communication elements and updating design models, field conditions, and assignments	Response to implementation elements, contract management request, design template update with changes	Monitor implementation stages and give inputs to changes in implementation	**LOD 400 – Fabrication & Assembly**
Model counter as per final design	Verification of standard and final form	Verification of standard and final form	---	**LOD 500 – As Built**
---	Preparing delivery documents	Coordination of information exchange through a utility group template	Share the interior designer and utility package for delivery	**Facility management**

6- The difference between the level of development and the level of detail.

The "level of detail" shows how similar the geometry and properties of the design model and the product are. Whereas, "level of sophistication" indicates the degree to which the semantic and engineering data associated with the BIM element were thought of. Where "development" represents the model regarding the amount of information provided at each stage of the project. ***(The Egyptian Code, 2018, P16).***

7- Results:

From the above, the following results can be reached:

- BIM contributes to cost estimation and schedules for all interior design, architecture and other disciplines and coordinates information in one integrated model.
- The use of BIM technology reduces costs associated with traditional energy, by providing information necessary for sustainable design, analysis, and certification routinely as a by-product of the standard design process.
- Building Information Modeling technology provides the opportunity to achieve many benefits in all stages of project design, interior and exterior design, building and implementation operations, and the post-occupancy phase of the building.
- Linking the construction model to energy analysis tools allows to evaluate energy use during the early design stages, and this is not possible using traditional two-dimensional tools, which require separate energy analysis at the end of the design process, thus reducing the chances of early adjustments that can improve energy performance in the building.
- Building information modeling systems and levels have developed significantly in all components of their systems in parallel to developments in the field of electronics, communications and information, which has made them appear to be highly appropriate to facilitate dealing with interior design projects as well through the application of sustainability standards.
- The use of BIM applications can greatly facilitate complex operations in sustainable design such as analyzing natural lighting, the movement of the sun around and inside the building, calculating the amount and intensity of lighting, as well as solar energy and automating work that requires effort.
- BIM contributes to the implementation and design of giant projects that cannot be implemented in any traditional ways that are characterized by complex methods that use the Parametric Design and prefab system technology and by producing machines with the support of CNC Numerical Control.

8- Recommendations:

- The research recommends the necessity of conducting many studies related to building information modeling and integrating it with the science of artificial intelligence, automation، and sustainability, in all fields of engineering and design.
- I recommend the responsible engineering organizations to develop procedures for implementing BIM technology in all mega projects as a major requirement.

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