Building Information Modeling (BIM) for Energy Efficiency Awareness in Gulf Countries

Ali Alhamami, Mohammed Awad Abuhussain and Yakubu Aminu Dodo

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Ali Hussain Alhamami
ahalhamami@nu.edu.sa
Najran University, College of Engineering, Civil Engineering Department
Najran, Kingdom of Saudi Arabia

Mohammed Awad Abuhussain
maabuhussain@nu.edu.sa
Najran University, College of Engineering, Architectural Engineering Department
Najran, Kingdom of Saudi Arabia

Yakubu Aminu Dodo
yadodo@nu.edu.sa
Najran University, College of Engineering, Architectural Engineering Department
Najran, Kingdom of Saudi Arabia

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ABSTRACT

Energy efficiency in the built environment has been adopted through several initiatives depending on the context of implementation; this paper further assesses Building Information Modelling (BIM) as a toolkit designed to tackle energy-related concerns in buildings. The paper leverages energy efficiency program cases of the gulf countries' level of BIM adoption. This case study design was qualitatively approached in which literature and authoritative contents were reviewed to ascertain the region's adoption of the technology as a body Gulf Cooperation Council. (GCC) and independently as a country (member states). It was identified that only Saudi Arabia and the UAE have BIM tied to their energy efficiency programs, unlike other member states that have energy efficiency programs with little or no trace of BIM. The GCC management committee is therefore saddled with the responsibility of implementing BIM. Utilizing BIM for sustainability will lead to significant savings through a combination of accurate energy monitoring, immediate decision support systems, actuators, and consumption form recognition.

Keywords: BIM, Carbon Rates, Energy Efficiency, Awareness, Gulf Countries, Gulf Cooperation Council

1 INTRODUCTION

At the national and European levels, tight laws and regulations have taken into account the necessity of reducing energy use and carbon emissions.(Alhamami, et al., 2020). Along with energy use, the building industry also contributes to greenhouse gas emissions, which in 2035 would total 42.2 billion tons, with 288 million tons produced annually in the UAE alone (British Petroleum Company, 2020).

The construction industry can help reduce low energy usage and make the process of global decarbonization as easy as possible. As a building or facility is designed, repurposed, built, and operated, numerous new professions in fields like energy and the environment are employed in addition to the traditional specialties and BIM, which refers to the process of collecting and managing data and knowledge about the building envelope all through the life cycle, from design concept to decommissioning, is one of the notable initiatives for reducing energy usage (Rezqui & Miles, 2011).

This research is combined with the knowledge bank of the Gulf States to determine their energy efficiency policies and whether or not Building Information Modeling (BIM), a crucial tool for efficiently regulating energy use and lowering energy costs is implemented.

2 CONCEPTUAL REVIEW

2.1 Building Information Modelling (BIM)

BIM is a tool that can be used to effectively work in terms of collaboration among the construction stakeholders. In essence help in managing energy. This modeling can significantly reduce energy use. BIM may complement how architectural design artifacts are formed and can significantly alter the collaborative process involved in the building. It also has a number of socio-technical benefits at both the process and technological levels. Utilizing the data produced throughout the facility life cycle and a uniform system is a technique for boosting output and effectiveness in the building industry (Choi, Shin, Kim & Kim, 2016).

BIM is described by PAS 1192-2:20131 as the "process of designing, constructing, or running a building or infrastructure asset utilizing computerized object-oriented information." BIM is now defined by the succeeding BS EN ISO 196502 as "the use of a shared digital model of a constructed asset to facilitate design, cost construction operation." Buildings, bridges, roads, and manufacturing facilities are examples of built assets. With this extra description, it is made clear that BIM is a help in sharing information amongst stakeholders in a visual manner.

Figure 1: Benefit of BIM in Construction (BigRentz, 2021)

BIM is one strategy for putting the challenge into practice (Seyis, 2020). One of the best methods for integrating building data and facilitating its administration over the whole building lifecycle is the BIM concept (Lu, et al. 2020). All project stakeholders, as well as the architectural, engineering, and construction (AEC) teams, may communicate and share information more simply with the use of building information modelling. NBS National BIM survey shows that 60% of those who responded to the survey thought that BIM cuts the life-cycle phase of construction by 50% (Wong et. al, 2015).

2.2 BIM for Energy Efficiency

By using BIM, it is possible to lessen greenhouse gas emissions, the amount of trash generated, and the energy used to create and operate buildings. Observable carbon dioxide emissions (Xu et al., 2020). BIM also includes specific elements that support energy efficiency goals from the design to field phases of construction, such as covering all aspects of the construction phases, especially the whole life circle (Soroush & Amani, 2011). Numerous features of BIM technology include visual analysis, collision checking, construction timeline simulation, and the development of practical construction design plans and scientific lighting techniques (Zhenshuang, Liguo, Ping & Xiaobo, 2015).

2.3 BIM Level of Details or Development (LOD)

The American Institute of Architects has identified six distinct levels of development (AIA). LOD explains the design parameters at each step, according to AIA (2019). In order to represent an element's existence at LOD 100, that is the pre-design stage, the model utilizes 2D symbols and masses. By describing the elements' approximative quantity, size, shape, and placement at LOD 200, they are partially specified. The elements are precisely defined by LOD 300. accuracy is reinforced by measurements and their relative locations. LOD 350 specifies an element's relationship to and relationship with other components as well as precisely describes an element's information. The fundamental details of the creation of various elements are described at the LOD 400 level. By LOD 500, the model starts to depict the actual uses of components in a real building.

2.4 BIM Dimensions

For use cases, also known as predefined special purposes, a BIM model can be applied. Control parameters are added to the data already present in BIM based on the project complexity and project stage requirements. BIM dimensions could be used to express these enhancements of pre-established utilised situations. With the help of these dimensions, data from a model can be improved in order to share a deeper understanding of a construction project. Each of the BIM dimensions—3D, 4D, 5D, 6D, and 7D—has a specific usage and is helpful for determining the cost, schedule, completion date, and sustainability of a project (United BIM, 2019).

2.5 BIM and Digital Twin

Digital twins are the key to controlling smart buildings, which are constructed using BIM. Because each of these intelligent platforms constitutes a digital reconstruction of the structure, there is some confusion between them. Their ability to support it is what distinguishes them from one another. BIM keeps design-build on schedule, within budget, and true to form. A well-designed structure can achieve and even surpass its goals with the aid of digital twins. Because smart buildings are only going to get smarter, they need intelligent software to support them over their entire life cycle. Together, BIM and digital twins can meet this demand, with each technology playing a crucial part in the build's planning, execution, and numerous subsequent uses (Spaceiq, 2022).

2.6 Gulf Countries/Gulf Corporation Council

The Gulf Cooperation Council is made up of six nations: the United Arab Emirates, Saudi Arabia, Oman, Bahrain, and Kuwait (GCC). There are 25 percent of the world's natural gas reserves and 29.4 percent of the world's oil reserves (British Petroleum Company, 2020). The GCC countries' increased primary energy consumption, which has overtaken Africa's total primary energy consumption despite having just one-twentieth the population of that continent, is clearly a reflection of this increase in population. Figure 1 depicts the primary energy usage between 1971 and 2011 in the various GCC nations (IEA, 2014). The United Arab Emirates is second, followed by Kuwait, while Saudi Arabia has the greatest share and GCC demographic shift, June 2012 (Doukas, Patlitzianas, Kagiannas, & Psarras, 2005).

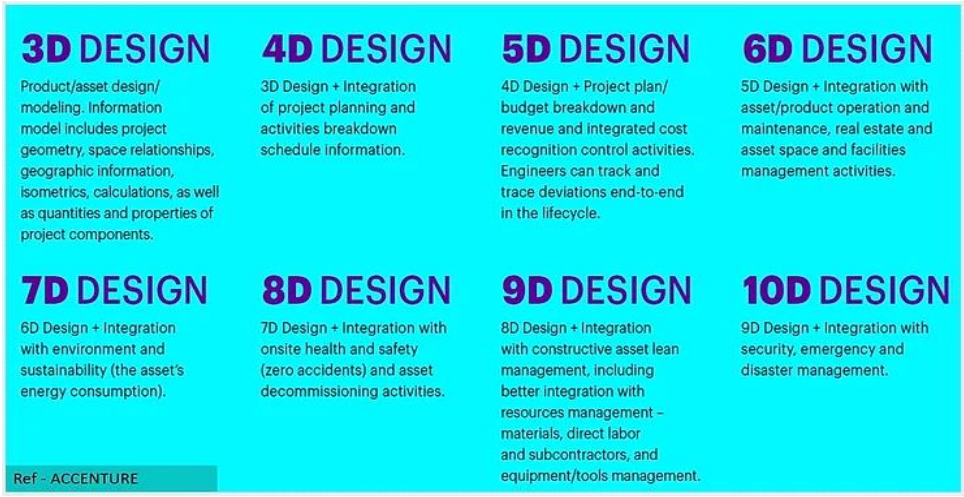

Figure 2: BIM Dimensions (Patel, 2020)

3 METHODS

This paper adopts a qualitative methodology of research to elicit data related to the variables of the study. This was done through in-depth desk reviews of relevant pieces of literature and contents related to understanding Golf Countries' energy efficiency awareness and the incorporation of BIM in its building and construction practices. The content review clusters the GCC based on the countries which were initially complimented with a holistic analysis of the GCC energy program as a body. Below is a tabulated illustration of the literature reviewed per GCC country to elicit their level of adoption of energy efficiency initiatives proposed and deployed.

Table 1: A Comparative Review of BIM for Energy Efficiency Awareness in Gulf Countries

GCC COUNTRY	LITERATURES REVIEWED	YEAR OF PUBLICATION	AUTHOR
Bahrain	National Energy Efficiency Action Plan	2017	NEEAP
Kuwait	Country's Datat: Statistics & Balances.	2014	International Energy Agency
	Energy Efficiency Program for the State of Kuwait	2020	Al-Mulla, A
Oman	The status of renewable energy in the GCC countries.	2011	Alnaser, W. E., & Alnaser, N. W.
	Renewable Energy Technologies: Cost Analysis Series	2020	IRENA
Qatar	The status of renewable energy in the GCC countries.	2011	Alnaser, W. E., & Alnaser, N. W.
Saudi Arabia	A literature review of the factors limiting the application of BIM in the construction industry	2017	Sun C, Jiang S, Skibniewski MJ, Man Q, Shen L
	Exploring the challenges in utilization of BIM in maintenance management of mosques.	2016	Sodangi, M., Salman, A.F, Shaawat, M.E
	Saudi's strategic vision for 2030.	2016	Hashmi, N.
United Arab Emirates	Renewable Energy Technologies: Cost Analysis Series	2020	IRENA
	Energy efficiency in the UAE Aiming for sustainability.	2020	Strategy&

4 RESULTS AND DISCUSSION

Gulf Cooperation Council: Energy Overview, Energy Efficiency and (BIM)

Only Oman has access to sufficient water resources to suit its needs throughout the year; the other GCC nations primarily desalinate seawater to produce drinkable water. As a result, water is more valuable than hydrocarbons and is more expensive per ton than oil (Aidrous, August 2014). There have been indications of a slowdown in demand growth since the GCC countries ratified the Kyoto agreement in (2005 and 2006), which called for legislative efforts to control GHG rise. However, efficiency gains outside the OECD region surged between 1995 and 2010. Energy demand increased by just 3.8% p.a. despite the economy expanding by 5.6% p.a., suggesting that energy intensity decreased on average by 1.7% p.a.

Case Study Findings: Gulf Countries Focus

4.1 Bahrain

The kingdom of Bahrain still uses a very modest amount of renewable energy in its energy mix, similar to the majority of GCC countries. Though no project has yet been built, the government expresses interest in renewable energy, particularly solar. For instance, Bahrain consumes around three times as much energy per person as the typical country, making it one of the top energy consumers in the world. Bahrain's power consumption varies significantly from season to season; from May to October, when temperatures are at their highest, consumption rises significantly. This is mostly because air conditioners are used heavily, using 60 to 65 percent of the country's electricity. The Bahraini government created the National Energy Efficiency Action Plan (NEEAP, 2017), which is one of the most significant steps the nation has taken toward more efficient energy consumption. The plan builds on previous successes and includes a wide range of initiatives to maximise future energy efficiency potential in the Kingdom.

4.2 Kuwait

In 2010, Kuwait's Total Primary Energy Supply (TPES) was around 23158 ktoe, natural gas accounts for the remaining 43% of the total. Crude oil accounts for 57% of this supply. In Kuwait, the summers are unusually long and the temperatures are very high. This has necessitated the use of air conditioning as a requirement for all kinds of structures, resulting in higher annual electricity consumption (kWh/year). A/C and lighting account for 85% of annual peak load and 65% of annual electricity consumption, and consumers pay about 5% of the actual cost of energy. The government has implemented several strategies in order to further establish a Kuwait that is energy efficient. These programs include the Energy Conservation Code of Practice (ECCP) and Energy Efficiency Technologies (EET) programs, which are noteworthy. While maintaining people's quality of life, the EET initiatives look for novel ways to reduce per capita energy consumption through the use of energy efficiency technologies in homes, companies, and power plants. With the help of the software, both new and ancient building constructions used less energy (Al-Mulla, 2020).

4.3 Oman

Looking at Oman's energy balance reveals that the country's main energy source is natural gas, which accounts for 73% of the Total Primary Energy Supply (TPES) and 27% of crude oil. Roughly 9218 ktoe, or 60% of Oman's total final consumption (TFC), was consumed by the industry sector in 2010. Transport used 2823 ktoe, or 18%, non-energy used around 12%, and other sectors including residential and services used the remaining 10% (Sweetnam, 2014). Large-scale renewable energy projects haven't been started in Oman yet. Despite a 100-200 MW solar project being announced by the Omani government, nothing has yet to be implemented (IRENA, 2012). The closest thing to implementation is a nine-month scoping project that has improved our comprehension of how energy is used in Oman and proposed a framework effective utilization of energy in a sustainable manner

4.4 Qatar

Like the other GCC countries, Qatar has considerable solar energy potential (Alnaser & Alnaser, 2011). Oil makes up the remaining 19% of the Total Primary Energy Supply (TPES), with natural gas making up the majority (81%). On the other hand, when examining energy consumption by industry, transportation and industry sectors account for about 60% of Total Final Consumption (TFC), while residential, commercial, and public services as a whole account for only about 8% of TFC and non-energy sectors account for the remaining consumption. There hasn't been a thorough investigation of how much energy is used in Qatari structures. However, building owners find it challenging to put even basic measures into practice due to a lack of specialists, such as trained operating engineers, materials, and energy-saving goods. Reducing the energy intensity of power use through the application of best practices in sustainable building for Qatar is one of the objectives of Qatar's Vision 2030 and Qatar National Development Strategy 2011-2016.

4.5 Saudi Arabia

Even though BIM is used in Saudi Arabia, it is still in its infancy and the country's building industry only occasionally uses it (Asif, 2016). This is because some business owners began to recognise the many advantages of utilizing BIM, such as the ability to enable a wide range of options for structures, the ability to run a wide range of tests on a model, and the ability to enable the early detection of deliberate mistakes to prevent costly rebuilds. A small number of significant firms use BIM mostly in Saudi Arabia's construction industry, which has a relatively underdeveloped subcontracting industry (Sodangi et al. 2016). BIM usage in Saudi Arabia is limited to a select few of the country's large enterprises, and the subcontracting sector there is dominated by small and medium-sized construction companies, thus it is necessary to develop methods that would certify the industry's adoption of BIM (Sun et al. 2017).

4.6 United Arab Emirates

The UAE has implemented a number of building efficiency initiatives. For instance, a program in Abu Dhabi called Estidama, which is the Arabic for "sustainability," supervises the planning, development, and use of structures through a series of licenses. In order to evaluate the sustainability performance of villas, buildings, and communities, Estidama also employs a rating system known as the "Pearl Rating System." The government of Dubai has released a set of green construction guidelines and specifications that include planning, resource use, material use, and waste. Notably, the standards aim to enhance the sustainability performance of buildings at every stage of their lifespans, from design through construction, use, and eventual demolition. Various programs and strategies have been introduced in the United Arab Emirates around 2011 (Strategy &, 2020).

5 CONCLUSION

This paper identified the establishment of energy efficiency programs independently in Gulf countries but sees the absence in the adoption of BIM except in Saudi Arabia and some traces in the UAE. Although other countries in the council have interrelated programs, projects, and initiatives and are growing fast in reducing carbon rates based on their contextual approaches. The GCC should therefore lead the establishment of region-wide energy efficiency initiatives taking in cognizance of member countries' areas of milestones for sub-coordination at the regional level (Alhamami, Rezgui, & Petri 2021).

Lessons should be drawn for the development of the BIM sub-sector in Energy Efficiency and further implemented in member states to ensure a uniform carbon rate reduction. The use of BIM for energy efficiency will lead to energy savings by fusing precise energy observation, real-time decision support systems, actuators, and pattern recognition. Additionally, (a) the application of a semantic method, such as (BIM, real-time data analysis, behaviour modelling), etc., (b) improved energy flows and use supervision in buildings, and (c) new collaborations between energy managers, energy equipment suppliers, energy distributors, and technology (including smart software tools), will help energy managers make the best decisions regarding the development of energy use in buildings and result in a quantifiable decrease in energy consumption in the GCC. The study also suggests that all GCC member nations adopt the strategy to fully utilize BIM, particularly to meet sustainability standards, with special consideration to energy efficiency in construction.

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