The Contribution of Building Information Modelling (BIM) to Green Building Design and Assessment in Abu Dhabi "ESTIDAMA"

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ABSTRACT

Estidama is a mandatory Green Building code in Abu Dhabi by which the compliance of building design is being assessed. This paper examines the current design and assessment approaches for Green Buildings to identify the reasons that lead to delay defects and it investigates a new approach for improvement. The available literature provides a realistic understanding to the problems and shows the road to some potential solutions. The identified problems were mainly attributed to the manual assessment with too much human interference. The piled documents with limited resources left the assessment system too slow to handle the whole projects within the greater Abu Dhabi engendering high risk of the commitment to review mistakes. Therefore, this paper investigates the potentiality of automating several stages via the use of Building Information Modelling (BIM) into the assessment process. Different experienced participants from all aspects within the construction industry were interviewed to contribute to the research. Also, a close question questionnaire was distributed to examine the current practice in Abu Dhabi to compare it with the initial findings. The findings point out significant requirements to adopt BIM in the assessment process, such as the availability of proper contracts form to shape the relationship between BIM parties and the readiness of the current system. Hence, the authors suggest a new model that integrates BIM capabilities within the system to accelerate the process and reduce human involvement.

KEYWORDS: Sustainability Assessment, Green Building, Building Information Modelling, Estidama, Process Automation

1. INTRODUCTION

Efficient approaches to deliver Green Designs play an essential role in achieving a successful project in the construction industry. Schueter and Thessling (2009) found that a around (40%) of the energy, used in the United States is consumed by buildings. On the other hand, sophisticated designs, complicated projects, and too many players involved within the design process, have made the dealing with the subject of Sustainability complex, especially with the use of conventional Computer Aided Design (CAD) methods. Nguyen *et al*. (2010) and Gleeson (2005) state that achieving Sustainability efficiently through conventional methods at the early stages of design becomes very difficult, if not impossible. In order to evaluate the building compliance with sustainability requirements at early stages, a vast amount of data about the building such as (materials, specifications, schedules etc.) needs to be approached in a cross-linked manner. BIM comes with its ability of cross informational exchange and readiness to real-time update.

Similarly, many studies such as Azhar (2010); Kriegel and Nies (2008) and BIM Journal (2010) have highlighted the benefits of BIM that can contribute to achieve sustainable outcomes, especially the

nature of BIM analysis and simulation abilities that match the objectives of Green Building. McGraw Hill Construction (2010) emphasized the high realization of industry towards BIM contribution to accomplish the sustainability objectives. On the other hand, growing of the green projects will drive more adoption of BIM. However, the level of convergence between BIM and Sustainability is still at the very initial stages. It has been concluded by some practitioners that the essential problems currently facing the construction industry to achieve Green Design are the delays, complexity of Sustainability assessment, human interference and the slow decision making from both the design and Authority sides.

This paper aims to discuss the problems associated with using the traditional methods to achieve Green designs and to highlight the main benefits of BIM that could contribute to enhance the sustainability assessment process in Abu Dhabi. It will investigate the obstacles that could hinder adoption BIM within Abu Dhabi environment, then examine the current level of adopting BIM into Estidama assessment process and identify the weakness of current procedures and processes. The Paper will suggest a common mechanism to determine the constants accepted by all involved parties within the process by using BIM tools such as online libraries that enable the design team to choose the proper materials to meet design needs and authority requirements at the same time.

2. DESIGN TOOLS AND APPROACHES TO ACHIEVE SUSTAINABILITY

2.1. Conventional (CAD) Methods

2.2.

Computer- Aided Design CAD is a program used for 2D and 3D design and drafting.. Although, the sustainable design and assessment can be achieved by using CAD method, this process can be painfully slow, inefficient, and requires long procedures that make achieving the sustainability assessment at early stage impossible. According to (Welland, 2009), Sustainability assessment result through traditional CAD methods can't be achieved until finalizing the construction documents at the best or even during the construction stage. Consequently, when conflicts and significant problems are discovered at later stages, the corrective action will consume more time and cost leading to a series of additional problems, including compressed schedules, design revisions and poor coordinated construction document sets. Accordingly, numerous (RFIs- request for Information) and (RFC-request for change) have to be issued. Such associated problems render BIM as an appropriate solution for most of the traditional design problems. The figure below shows how BIM helps to solve the problems at an early stage and reduce the design change cost.

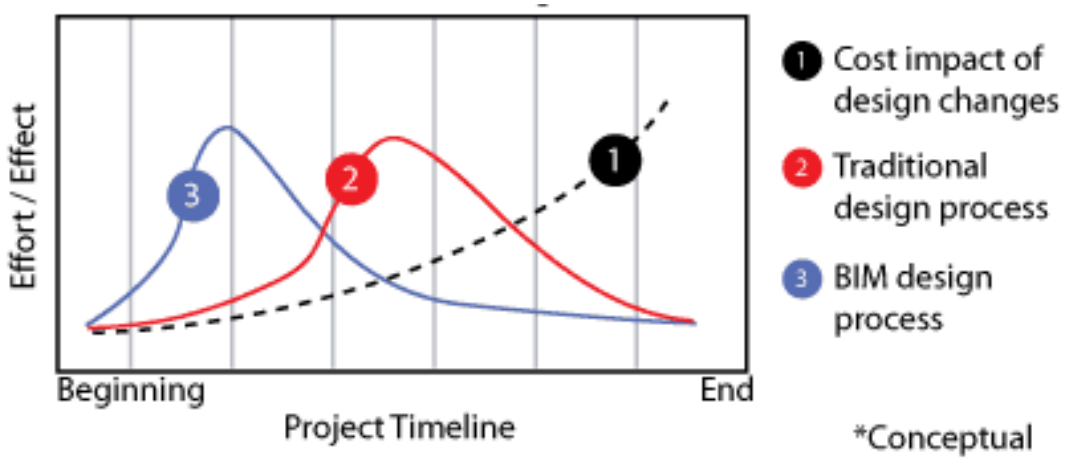

Figure 1, BIM process shifts the Design Curve. Source: (Welland, 2009).

CAD method has some advantages that make some projects' participants cling to it, such as the friendly use of tools and low cost of software. The disadvantages of traditional CAD methods come from the CAD documents characteristics where in CAD, the documents are fragmented, separated and lack automatic cross references in addition to being exposed to excessive human intervention, since any update of single requirements need to be reflected manually in other affected elements. CAD elements are always implemented independently without intelligent connections, and they also lack coherence of consistent information that makes them susceptible to mistakes and duplication that might not be discovered until the construction stage.

2.3. Building Information Modeling (BIM)

Building Information Modeling (BIM) is a set of powerful tools recognized by (AEC) Architecture, Engineering, and Construction Industry. BIM grants the ability to influence the project design at different stages concurrently, in addition to its positive results for construction and operation. BIM's features enable obtaining project information such as: scope, time schedule and cost in a prompt, smooth and continuous series, while at the same time, providing a high-quality, consistent, and reliable referencing system. BIM has numerous features that qualify it to be a powerful tool to improve Sustainability throughout the project life cycle. The integrated and coordinated database that is contained within the building elements, provides a significant support to sustainability assessment by enabling capturing of the required information during different design stages as required. However, not all BIM benefits have equal impact, especially on Sustainability assessment. Firstly, BIM can reduce the work that is required to evaluate multiple alternatives at an early stage (Bank *et al*. 2010). The same author refers to the bilateral relationship between BIM and environmental Software where BIM model can be easily exported to other environmental assessment software such as "Ecotec and Green Building studio" that enables energy and daylight analysis, which can improve the sustainability assessment process.

Capper *et al*. (2012) mention the ability of BIM to evaluate CO2 emissions for a project throughout its life cycle. Sheth *et al*. (2010) argue that the ability of BIM to provide information like travel distance will prove the energy demand and solar computations. Sheth *et al*. highlight the 3D- visualization and walks through as another benefit of BIM that can convince the client and stakeholders to use some energy element such as solar panels, by offering proper locations without any disturbance to facades, architectural building form and surrounding areas. Although Some BIM benefits like the materials waste reduction cause loss of green credit points due to reducing the chances of using re-used materials. However, BIM's ability to monitor quantity of materials contributed directly to the elimination of waste during construction adding significant value to the sustainability.

Although many studies such as McGraw (2010) and Azhar *et al*. (2011) demonstrated some obstacles and barriers that could face the adoption of BIM, since some of them lacked the objectivity to evaluate the problem, they ignored obstacles that could hinder the adoption of BIM like the legal factor. The challenge is to have proper contract formats that are able to accommodate the shared responsibility of parties when a document is produced or changed. A proper determination of BIM ownership and how to maintain copyright are additional examples of legal ambiguity. The key party that controls data inputs as well as the revisions into BIM model whether to be liable for defects and mistakes is another concern, especially, as BIM approach adopts the collaborative team work which blurs the responsibility level between parties leading to potential disputes. In addition, the revision and modifications date are not clear when it is all loaded to the same model.

BIM is a new concept, and because of that, the availability of similar cases inside legal courts are untested which may add more complications. Unfriendly software tools, especially for high experienced people with conventional CAD software, can cause high resistance to such change among seniors. BIM software doesn't come with gradual solution that can bridge gaps with a smooth transition between CAD and BIM. Other studies like (McGraw Hill Construction, 2010) and (BIM

journal, 2009) considered the financial crisis as a drive to implement BIM in order for companies to find new areas of competition. Opposition can be expected from clients and developers to spend extra money to implement the new approach.BIM has many characteristics that make it a successful substitute to the traditional methods, especially with the robust of sustainable design. Nevertheless, this approach comes with some disadvantages that hinder its adoption. It is recommended that BIM software developers provide such applications with more user-friendly tools. All concerned parties work closely to identify and avoid current BIM problems such as finding appropriate legal formulas to describe the contractual relationship between all parties, in order to make BIM suitable to all expected cases and to be combined with the current contract forms or at least be added as addendums.

3. SUSTAINABILITY ASSESSMENT STANDARDS

Human beings recognize the pressing need of "Sustainability". According to Allen (1980), the most common definition of sustainability is the process to improve the quality of human life. In addition, there is the ability of community and ecosystem to continue performing in the future without depletion of the key resources of this system (Haviland, 1994). This is how the word sustainability inspired Abu Dhabi regulators when Estidama system was created, as the Arabic translation of Sustainability.

In order to achieve the aim of sustainability, the impact of building construction on the environment needs to be assessed. There are currently different adopted rating systems such as "*BREAM in UK* and Netherlands; *LEED* in United States and Canada, and recently ESTIDAMA in Abu Dhabi, UAE. Many of these assessment systems in principle rely on similar criteria such as building energy consumption, material utilization, water efficiency and level of internal environment comfort. Estidama focuses on four aspects that are considered as pillars that shape the assessment approach and differentiate Estidama from other Sustainability Assessment.

Estidama promotes a unique methodology of assessment called "Pearl Rating System". Three different pearl rating systems exist, including different sets of measurements to suit buildings, communities and villas separately. Each one consists of three phases: Design, Construction and Occupation. Seven categories are targeted by the Estidama Rating System with different weightage based on importance of each category for Abu Dhabi environment. The categories are: *"Integrated Development Process, Natural Systems, Livable Buildings, Precious Water, Resourceful, Energy, Stewarding Materials, and Innovating Practice."*

To achieve the sustainability assessment level in Estidama "pearl rating level", clients or consultants are required to undertake certain steps. After Pearl rating application submission to UPC, it will go through different steps starting with Estidama team review. The current green building assessment and permitting are criticized as being slow and complicated due to long procedures associated with the assessment processes in addition to multiple disciplines involved which may lead to complicated communications along with human interference. In addition, there are some iterative chains which may mean other internal long loops if assessment is not achieved in the first time.

The pearl rating assessment can be significantly enhanced through integrating BIM into its process due to numerous tools and features contained within BIM which are able to execute many important stages like energy, daylight and site analysis, water usage etc. Consequently, the design team will be able to assess the sustainability level of the project and make the required modification at an early stage to meet the required sustainability level before submitting it to authority for their review and assessment. Long iterative loops that consume time, in addition to significant human intervention by assessors will be eliminated. The next figures highlight the stages that can be minimized due to BIM intervention.

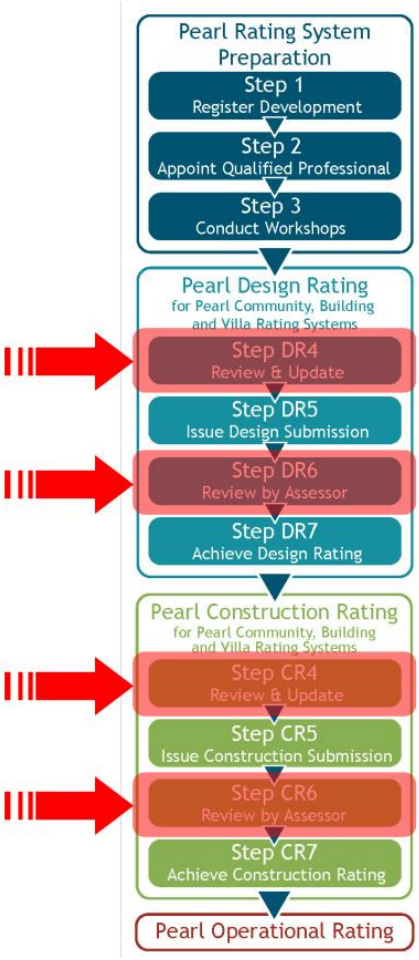

Figure 2, the Pearl Rating Process after applying BIM

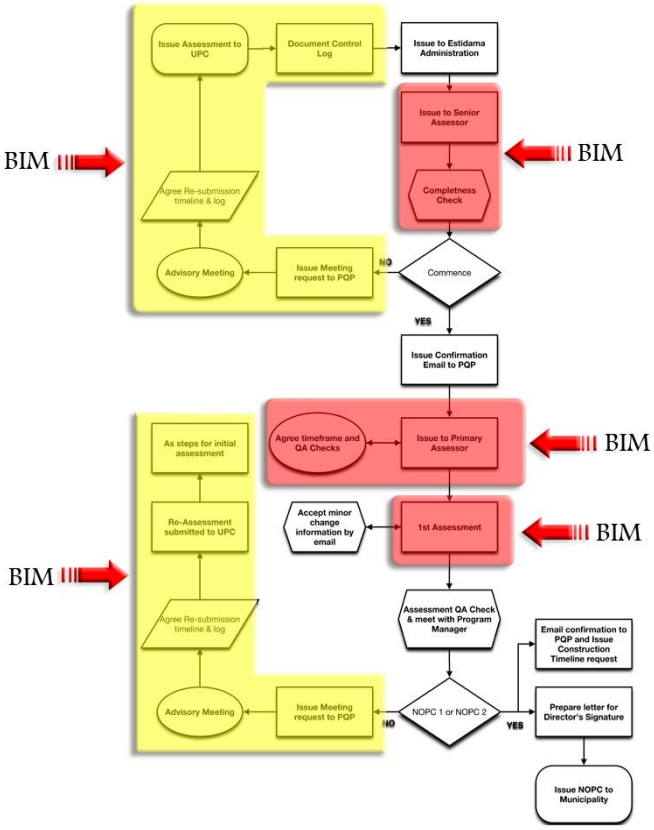

Figure 3, flow chart of review process for project targeting to obtain 1or 2 pearl after applying BIM.

Before establishing any relationship between BIM and any sustainability system, initial analysis of the criteria of that system are required in order to convert them to parameters that building model can deal with. Two main types of sustainability data are required for the sustainability assessment. 1) The quantitative data which are described by mathematical values such as the energy and water consumption, air pollution and day light. This kind of information can be easily treated by building model. 2) The qualitative data which covers issues such as the impact on geological and cultural aspects and considered more complicated because it relies on subjective judgment rather than facts which will vary among different stakeholders (AlWaer *et al.*, 2008). By identifying the areas that BIM through its features and capabilities can help to achieve the credits' requirements, the authors developed a model as shown at the table below to represent the potential relationship between Estidama credits and BIM. Although the table shows the integration areas between BIM and Estidama for only one credit category, all other credits categories can be analyzed to identify the relationship in similar way.

Credit Reference	Credit Title	Credit Points Available	Energy Analysis	Day light Analysis	Water Usage	Solar analysis	Thermal simulation	Parametric Components	Material specs	Site Analysis	value/ cost analysis	Automatic calculation&scheduales	Automatic layouts
RE	Resourceful Energy												
RE-R1	Minimum Energy Performance	Required	■	■	■				■			■	
RE-R2	Energy Monitoring & Reporting	Required	■					■	■			■	■
RE-R3	Ozone Impacts of Refrigerants & Fire Suppression Systems	Required							■				
RE-1	Improved Energy Performance	15	■										
RE-2	Cool Building Strategies	6	■	■		■		■	■	■		■	■
RE-3	Energy Efficient Appliances	3						■	■			■	
RE-4	Vertical Transportation	3						■	■				■
RE-5	Peak Load Reduction	4	■										
RE-6	Renewable Energy	9	■			■		■					
RE-7	Global Warming Impacts of Refrigerants & Fire Suppression Systems	4							■				
	TOTAL	44											

Table 1, Proposed interaction areas between BIM and Estidama credits for Resourceful Energy credits.

4. RESEARCH METHODOLOGY

Two kinds of data were approached to collect the paper information: secondary and primary data. The secondary data was approached through exploring the existing academic literature and extracting information related to the research, especially that which targeted BIM and Sustainability. This information gives the basis of the research. However, relying only on the secondary data is not enough to achieve the objective of the paper as many gaps would be there. Therefore, primary data was also collected to reinforce and bridge the gaps of secondary data. Primary data was approached through two parts; Qualitative semi-structural interviews that were conducted with senior executives from different disciplines within the UAE construction industry (Authority, Consultant, Suppliers, and third parties specialists in Green Buildings).. The main purpose of these interviews was to establish a better understanding of the topic and get a professional insight from the UAE, especially the Abu Dhabi construction environment. Based on the collected information through interviews, well-structured questionnaire was built and disseminated among practitioners in the UAE to form the second part of the primary data. The Questionnaire online link was sent to more than 300 professionals within the UAE construction industry through emails. In order to ensure the relevance and validity of responses, participants were chosen from the five targeted disciplines (Governmental and Authority bodies, Owners and Developers, Consultants, Contractors, Suppliers and Manufacturers).

5. SURVEY RESULTS AND ANALYSIS

5.1 Personal Interviews

All interviewees agreed that in principal, the automation should accelerate Estidama Assessment process. Some have emphasized BIM, while mandating the approach faced debatable arguments from each party from its interest point of view. Moreover, some aspects were preferred over others depending on the nature of each participant's business. Manufacturers for instance, were concerned about their products' certifications, while consultants sought real time decision-making during energy model design for instance. The Authority representatives were mostly concerned about the flow of the process and number of assessors to handle each stage. Anyway the opinions of interviewees come to emphasize the literature findings level of collected information accuracy.

5.2 Questionnaire

86 responses out of 300 professionals that have been targeted were responded; their response was received and analyzed. The Majority of respondents were professionals in THE UAE, One quarter of the participants were highly experienced (above 15 years) in addition that most of them (73%) were in senior or executive positions at their organizations. This can give good indication for the effectiveness of the results on the industry due to the rich information of this category in addition to their influence in decision making at their companies. However, doubts may arise about the credibility of the information of how this percentage of senior and excusive positions was achieved, but, knowing that targeting such category was taken into account during distributing will clear the pasture.

The importance level of the main benefits that can be achieved through implementing BIM was offered for rating. The most ten important benefits were chosen correlated with the literature review in addition to the interviews with the specialists. The overall average score of importance level of the ten benefits was 62% (Table 2). This result reflects the good level of realization of BIM benefits within the UAE construction environment where all benefits came from average to high importance level by the majority. However, some benefits like (Reduction in design and detailing errors, clash detection and less rework, and reduction in waste and materials) were rated by the majority of participant as a maximum benefit, this might be attributed to the fact that most of the participant were from consulting backgrounds where these benefits are directly in touch with their scope. Nonetheless, compared with the literature review insight, the overall realization of BIM benefits were below the expectations.

Kindly rate the main benefits of using BIM in an organization : (5 refers to more benefit)						
	1	2	3	4	5	Response Count
Accelerate and enhance the sustainability Assessment	1.2% (1)	9.6% (8)	**31.3% (26)**	28.9% (24)	28.9% (24)	83
Direct integration with energy analysis	6.0% (5)	7.1% (6)	**29.8% (25)**	**29.8% (25)**	27.4% (23)	84
Improved productivity	1.2% (1)	13.4% (11)	29.3% (24)	23.2% (19)	**32.9% (27)**	82
Reduction in design and detailing errors	2.4% (2)	7.2% (6)	20.5% (17)	27.7% (23)	**42.2% (35)**	83
Improved communication	1.2% (1)	6.0% (5)	26.2% (22)	**41.7% (35)**	25.0% (21)	84
clash detection	1.2% (1)	7.2% (6)	31.3% (26)	21.7% (18)	**38.6% (32)**	83
Increased ROI	4.0% (3)	12.0% (9)	**41.3% (31)**	21.3% (16)	21.3% (16)	75
Less rework and reduction in waste - materials	2.4% (2)	8.5% (7)	29.3% (24)	23.2% (19)	**36.6% (30)**	82
Fewer RFI's	2.5% (2)	20.3% (16)	**31.6% (25)**	24.1% (19)	21.5% (17)	79
Improved quality control	3.5% (3)	7.1% (6)	24.7% (21)	**35.3% (30)**	29.4% (25)	85
					answered question	**86**
					skipped question	**0**

Table 2, rating the main benefits of using BIM

Main obstacles facing BIM implementation were also rated. Based on the literature review and the results of the interviews, ten obstacles were considered to have the highest impact against implementing BIM. The overall average score of the selected obstacles importance level was 54% (Table 3). This finding represented important influence by these obstacles to hinder implementing BIM. The majority of participants have considered the two obstacles (Senior Management buy-in and availability of skilled staff or sufficient training) as the higher amongst other obstacles whilst, considered interoperability and cultural issues like the resistance to change as the lower. This requires high attention towards the senior management buy-in and plan to rise up the skills of managerial staff within the UAE by the intensive training programs without forgetting the cultural issues. Moreover, this finding provides a good sign about the level of collected information accuracy since it supports the literature information.

Kindly rate the main obstacles against successfully implementing BIM in an organization: (5 refers to high level)

	1	2	3	4	5	Response Count
Cost of software and Hardware	6.0% (5)	13.1% (11)	**35.7% (30)**	25.0% (21)	20.2% (17)	84
Senior Management buy-in	2.4% (2)	9.5% (8)	32.1% (27)	**34.5% (29)**	21.4% (18)	84
Availability of skilled staff or training	4.7% (4)	8.2% (7)	27.1% (23)	**34.1% (29)**	25.9% (22)	85
Disruption to current process	4.9% (4)	22.0% (18)	29.3% (24)	**31.7% (26)**	12.2% (10)	82
Lack of proper contractual forms	9.6% (8)	14.5% (12)	**42.2% (35)**	21.7% (18)	12.0% (10)	83
Unfriendly use/ difficult tools	14.3% (12)	16.7% (14)	**36.9% (31)**	20.2% (17)	11.9% (10)	84
The current conventional methods are more easier	15.3% (13)	16.5% (14)	**29.4% (25)**	28.2% (24)	10.6% (9)	85
Lack of seamless transition mechanisms to the new approach	8.4% (7)	13.3% (11)	**39.8% (33)**	24.1% (20)	14.5% (12)	83
Interoperability: inability for different software packages to work together	10.0% (8)	26.3% (21)	**33.8% (27)**	16.3% (13)	13.8% (11)	80
Cultural issues/ resistance to change	9.9% (8)	**25.9% (21)**	24.7% (20)	23.5% (19)	16.0% (13)	81
					Other (please specify)	4
					answered question	**86**
					skipped question	**0**

Table 3, rating the main obstacles against successfully implementing of BIM

Main BIM features that can help achieve green objectives were also offered for rating. It was found that the total average score of 63% about BIM features was below the expectations in light of the initial findings. However, the large number of features supporting the sustainability objectives in addition to the rating average of each feature which didn't go less than 60% give a good sign of the expected advantages towards Green Building that can be achieved through integrating BIM with Sustainability. The average rating for all features is almost within the same range (60-69%) which contradicts with literature signals which considered that different BIM features had different impact on

the sustainability. This can be referred to the lack of knowledge of each feature. However, the majority of participant (40%) give very high rates of importance to Energy Consumption simulation and they also rate the light & water usage as high which came in line with the literature findings. On the other hand, rating parametric components as a medium importance contradicts the interviews findings.

Kindly rate the main BIM features that can help achieve green objectives: (5 refers to more achievement)

	1	2	3	4	5	Response Count
Energy Consumption	3.5% (3)	8.1% (7)	15.1% (13)	32.6% (28)	**40.7% (35)**	86
Light Analysis	2.4% (2)	7.1% (6)	20.2% (17)	**44.0% (37)**	26.2% (22)	84
Water Usage	1.2% (1)	8.3% (7)	25.0% (21)	**38.1% (32)**	27.4% (23)	84
Parametric Components	0.0% (0)	10.0% (8)	**33.8% (27)**	30.0% (24)	26.3% (21)	80
Programming/ Scheduling	2.4% (2)	16.9% (14)	16.9% (14)	**37.3% (31)**	26.5% (22)	83
Material Takeoff	1.2% (1)	9.6% (8)	**33.7% (28)**	28.9% (24)	26.5% (22)	83
Clash detection	2.4% (2)	8.3% (7)	**36.9% (31)**	20.2% (17)	32.1% (27)	84
Pre fabrication	2.4% (2)	9.4% (8)	34.1% (29)	**37.6% (32)**	16.5% (14)	85
Collaborative team work	1.2% (1)	7.1% (6)	28.2% (24)	**34.1% (29)**	29.4% (25)	85
3D Visualization	2.4% (2)	10.7% (9)	27.4% (23)	**31.0% (26)**	28.6% (24)	84
Coordination	2.3% (2)	2.3% (2)	27.9% (24)	**33.7% (29)**	**33.7% (29)**	86
Efficient communication	1.2% (1)	6.0% (5)	28.6% (24)	**39.3% (33)**	25.0% (21)	84
Standardization	1.2% (1)	6.0% (5)	25.3% (21)	**36.1% (30)**	31.3% (26)	83
					Other (please specify)	2
					answered question	**86**
					skipped question	**0**

Table 4, rating the main features of BIM to achieve Green objectives

More than 90% of participants agreed that the current high demand of Green building will lead to more adoption of BIM. On the other hand, almost the same percentage of participant agreed about contribution of BIM adoption to achieve Greener objective. This finding emphasizes the controversial relationship between the two approaches and gives a clear indication to the inevitability of integration between them. Moreover, this high realization from the industry towards these concepts comes in line with the literature findings as well as highly supporting the objectives of this research giving a positive indicator to proceed with its concept. However, this finding will contradict in somehow with the findings where the majority of participants expressed a moderate difficulty of current Estidama procedures. Depending on the initial findings, it was found that current Estidama procedures are not benefiting from BIM. Also, complicated procedures and processes that required more human intervention lead to time consuming and inefficiency. Nevertheless, the other findings where the majority of participants (83%) give moderate to high rating, agree that BIM will lead to significant cost saving throughout the whole project life cycle which come in light with the literature finding to support the proposed approached of this paper.

The analysis of the collected information leads to a conclusion that the majority of results came in line with the literature review. However, there are limited areas that either contradict with literature review or other survey findings which refer to the level of confusion or lack of knowledge towards some important factors due to the novelty of the topic within the UAE. As a sample of these areas is the rating of satisfaction level of current Estidama processes and of the current level of BIM adoption. Also, there are some findings especially from the Interviews which have enriched the research by adding some factors like the possibility of quantifying some qualitative information required by assessment to reduce the human interference as well as reducing the consumed time and increasing the level of efficiency.

6. CONCLUSIONS AND RECOMMENDATIONS

This paper has discussed many problems associated with Conventional Methods to achieve green designs such as lack of consistency, coherent and cross referencing, fragmental process etc. This paper has also highlighted the main benefits of BIM that could contribute to enhance the sustainability assessment process in Abu Dhabi, especially its ability to store tremendous information within the model through having parametric components. The Sustainability information is part of this information. Despite the multiple benefits of BIM that can improve the Sustainability system, this paper investigates some obstacles and barriers that can hinder the successful implementation of BIM, such as the lack of proper contractual relationship between BIM parties, existence of clear format to different revisions and updated permits. The paper demonstrates how Estidama assessment process currently lacks the integration with BIM approach, neither with its processes nor the permitting system. It also identified several weaknesses within Estidama current procedures and processes, especially the extensive human interference that is associated with its process which causes delays and increases the risk of mistakes and the complication and slowness of this process. However, the paper states that implementing BIM into Estidama processes will significantly improve its processes through many enhancements such as automation of important stages of the process which leads to minimize the human interference and review process. The paper recommends that all concerned parties should buy-in the approach to maximize using BIM especially to achieve the sustainability requirements. Authority should lead the process of change by issuing proper legislations that lead to mandate BIM to certain level such as for extensive projects and/or big organizations. Authority should also lead a proper voluntary system for other levels by offering incentives to encourage clients and other parties to increase training programs and simplify the tools of BIM benefiting from CAD existing tools and to create friendly interface to bridge the gap between the two approaches. Also, appropriate mechanisms to maintain smooth transition from the conventional methods towards BIM approach should be studied and adopted. The government should develop a framework for BIM-based Estidama software in coordination with BIM solution providers and other concerned parties.

7. REFERENCES

Abu Dhabi Council for Economic Development (2009), *The Abu Dhabi Economic Vision 2030*, Abu Dhabi's Economic Policy Priorities-Section one.

Abu Dhabi Urban Planning Council (UPC), (2010), *Abu Dhabi Vision, Plan Abu Dhabi 2030*, urban Structure Framework Plan.

Abu Dhabi Urban Planning Council (UPC), (2010), *Estidama A to Z, Description of characteristic programs and components within Estidama*, August 2010.

Allen R. (1980), *How to save the world. Strategy for world conservation*. London: Kogan.

AlWaer, H. Sibley, M. and Lewis, J. (2008) *Different stakeholder perceptions of sustainability assessment*. Architectural Science Review, July 01.

Azhar, S. (2010). *BIM for sustainable design: results of an industry survey*, Journal of Building Information Modeling V.4 (1), 2010, 27–28.

Azhar, S. Carlton, W. Olsen, D. Ahmad, I. (2011). *BIM for sustainable design and LEED® rating analysis*, Journal of Automation in Construction V.20 (2), March (2011), 217–224.

Azhar, S., Hein, M., and Sketo, B. (2008). *Building Information Modeling: Benefits, Risks and Challenges*. Proceedings of the 44th ASC National Conference, Auburn, AL, April 2-5.

Bank, L. C., McCarthy, M., Thompson, B. P., & Menassa, C. C. (2010). *Integrating BIM with system dynamics as a decision-making framework for sustainable building design and operation*. Proceedings of the First International Conference on Sustainable Urbanization (ICSU)

BIM Journal (2009). *BIM implementation learning from the mistakes of others*, issue 7-case study August 1, 2009

BIM Journal (2010). *Emerging trends in the construction industry, Improving the construction process*, issue 21, Article 1, Oct 1, 2010

BIM Journal, (2010). *Integrating BIM and LEED, Improving the construction process*, issue 30, Article 2, Oct 29, 2012

Capper, G., Matthews, J., & Lockley, S. (2012). *Incorporating embodied energy in the BIM process*. Presented at the CIBSE ASHRAE Technical Symposium, Imperial College, London UK, London.

Estidama, (2010), *Submitting a Pearl Rating Application* [Online].Available: http://estidama.org/submit-project/submitting-a-pearl-rating-application.aspx

Gleeson, J. (2005) Computer-aided green design, Architecture week

Haviland, D. (1994) *The architect's handbook of professional practice*. Washington, DC: American Institute of Architects Press.

Kriegel, E. Nies, B. (2008), *Green BIM*, Wiley Publishing, IN, Indianapolis.Liu, A. Fellows, R., Research Methods for Construction

McGraw (2010), *Green BIM: How Building Information Modeling is contributing to Green Design and Construction*, Hill Construction Smart Market Report

Nguyen, H. Shehab, T. and Gao, Z. (2010), *Evaluating Sustainability of Architectural Designs Using BIM*, The Open Construction and Building Technology Journal V.4, 2010, 1-8.

Sheth, A. Z., Price, A. D. ., & Glass, J. (2010). *BIM and refurbishment of existing health care facilities*. Proceedings of the 26th Annual ARCOM Conference, 6-8 September, Leeds, United Kingdom. Presented at the ARCOM Conference, Leeds, UK: ARCOM.

Schueter, A., and Thessling, F. (2009). *Building Information Model Based Energy/Energy Performance Assessment in Early Design Stages*". Automation In Construction

Welland, R. Briggs, G. (2009) *The Intersection of BIM and Sustainable Design*, Structure Magazine, March 2009, 16-17