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ENERGY SAVINGS THROUGH THE APPLICATION OF BUILDING INFORMATION MODELLING (BIM): A PILOT STUDY

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Abstract: *In order to ensure the public universities in Malaysia to achieve sustainable energy in the future, these universities should start a program of energy saving by exploring new technology of Building Information Modelling (BIM). Evaluation of the pre-retrofitting lighting performances are needed to ensure an effectives energy saving for these universities through measurement with the integration of BIM. As part of technical solution, this paper will investigate the energy performances on actual condition of existing building in a university through the adoption of BIM. The aim of this research is to improve the energy performance in an existing university building with the adoption of BIM with the aim to save the energy. Energy performance can be improve by reviewing the energy usage of many appliances in the building, importantly lighting. To achieve the objective energy performance, this university building will be reduce the cost, increase in value and contribute more productivity sustainability environment to campus users. This paper will identify the potential strength and weaknesses of applying BIM through energy performance process during the pilot study. The outcome of this paper will be used to determine the potential of BIM in the existing university building in order to improve energy performance. Therefore, it will improve the works of the maintenance department in universities to check their work through digital application that will provide more accurate energy readings.*

Keywords: *Building Information Modelling (BIM), Energy Performance, Lighting, Public Universities, Pilot Study.*

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Introduction

In Malaysia, based on Building Energy Index (BEI) a Malaysian public building especially office type approximately achieves 269 kWh/m^2/year. Therefore, existing building need to improve in term of saving energy performance practice. The first stage of construction begins with the process design. Thus, the current state of modernization in digital can help illustrate the actual design that will take place in the final stages of construction (Aljundi K., et al., 2016). In early design stage, to avoid mistake happened a better management strategy planning during produce an information are most important thing in a lifecycle project (Mohammad N.L., 2000). The emergence of BIM digital model software similar to that of the real world has been widely used in every construction company nowadays. Therefore, the details information get from consultant can also be updated using BIM application tool details. All information collected can be managed in a way that is relevant to the project lifecycle. Collaboration on a one-to-one basis parties is most important thing because the information that runs will be parallel presented during project progresses. Therefore, coordination between the parties involved professionals can be efficiently carried out to achieve the project goals using the BIM methodology and tools provided. BIM is a work methodology based on digitalization and collaboration between agents throughout the entire life cycle of a building or infrastructure (Boton. C., et al. 2015). With BIM, the energy consumption is an integrated part of building design, where energy analyses begin at the conceptual stage of the project (Gao, H., et al.,2019).

Literature Review

The energy performance in the building is basically related to the electricity usage in the building. The electricity overall performance of a building is "the calculated or measured quantity of energy to meet the electricity call for related to an ordinary use of the building, which incorporates, power used for heating, cooling, ventilation, heat water and lighting fixtures (Directive, 2010). According to Dubois M. C. et al. (2011) carried out literature study on strategies for effective usage of electrical lighting. He stated that Cost effective energy saving may be achieved by simply replacing and planning the electrical lighting installation. Experimented a case study from an architectural practice on how BIM design models can be used for building performance analysis, focusing on orientation and shading studies, the performance of shading devices, solar access analysis and daylight simulation, Aksamija A. et al. (2012). Building Information Modelling (BIM) has seen a dramatic increase in use in the design and construction industry over the last few years due to its ability to foster collaborations among many disciplines. BIM can be used to accelerate the extraction of knowledge accumulated in a number of simulations that can be used to define product development standards and recommendations. Nowadays, construction projects and building industries are becoming increasingly complex, especially in terms of modern construction and unique design alternatives. Building Information Modelling (BIM) is another technology which integrates management paradigms such as critical chain project management, critical path method, lean and concurrent engineering with some software like Primavera, Revit, Navisworks and others (David E. & Blake. S., 2011). It is an exact representative from information revolution so that associates composition of processes to make, communicate, virtualizes, scrutinize, collaborate, coordinate and integrate building models. Building Information Modelling (BIM) is generally understood as an overarching term to describe a variety of activities in object oriented by using Computer Aided Design (CAD), which is to support representation of building elements in term of 3D geometric and functional attributes and relationship (Ghaffarianhoseini, A., et.al, 2017). Thus Building Information Modelling (BIM) refers to a set of technologies and solutions aiming to enhance inter-organizational collaboration in the construction industry, that will enhance

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productivity whilst improving the documentation, design, construction and maintenance practice (Miettinen. R., et. al., 2014).

Figure 1: BIM methodology dimensions.

(Sources: Biblus, 2017)

Currently, two dimensional (2D) plan is familiarity on construction industry practice nowadays. In addition, there are not only Building Information Modelling (BIM) maturity level. Therefore, not only, the understanding of construction people who are not from the BIM world who only know Building Information Modelling (BIM) is the conversion from the 2D plan to the 3D model but many more levels of information are translated into Building Information Modelling (BIM) among them are as below: 3D a dimensional modelling, 4D: focus on duration analysis or work programme, 5D: cost analysis, 6D: sustainability assessment & 7D: focus on facilities management phase of what has been achieved. Malaysia has been coordinating gradually in implementing the construction industry, Construction Industry Development Berhad (CIDB) 2014 and Public Works Department (PWD) 2017. The Public Works Department (PWD) has now released the standard properties that have been used as guidance in the construction of projects under the Public Works Department (PWD).

Building Definition in BIM for Energy Simulation

In this section, it is necessary to define all the data required to carry out the energy simulation of the health centre with the BIM software. First, the building plans were used in "dwg" (Autodesk, 2020) format, which served as a template for the construction of the building's geometry and BIM architecture using the REVIT program. Once the architecture and structure model was obtained, the envelop of the building, the operational and occupational characteristics of all the spaces were configured to obtain the energy model, also with the REVIT software.

Case Study

The Administration Building of the University Technology MARA (UITM) Tapah Perak is a one of the branch campus (UITM) in Perak. The construction of the administration building dates from 2014, as a new concept design from architect. Main contractor for this building is from Crest Builders Sdn Bhd. The building for administration is fully occupant by Administrative Staff and also Academic Staff. The occupant for this administration building is

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applied normal working hours same with others public office building or administration building. Administration Building UiTM Tapah is one of symbolic building design by architect. The roof look floating located at front lobby area for this building. Material for roof is a metal deck. The type of structural support for roof is a lattice girder. The floor is very long rectangular and has 3 floors above ground. The total gross floor area (GFA) is approximately 3654m². The structural building is made of a reinforced concrete structure and the wall of the interior and exterior surface is a basic plaster both sides with interior paint and weather shield paint for exterior.

Figure 2: General view of the administration building in the University Technology MARA (UiTM) Tapah

Description of the Building Facilities

The luminaires in the building are mostly fluorescent lamps. It does not have control elements for interior lighting or daylight (Doulos, L., et. al., 2019). The production of cold ventilation for air conditioning is carried out by means of chillers per direct expansion floor with ducts and additional 4 numbers of split units.

Architecture Model of the building

Figure below shows the BIM architectural model of the Administration Building, UiTM Tapah, which consists of 255 spaces, with 266 windows and 122 doors.

Figure 3: Architectural model of the building in NAVISWORK software

Building Energy Model (BEM)

With the architectural model and also using the REVIT software, the energy model of the building was obtained, where the air conditioning system was defined, and the energy configuration of the building was carried out, and its occupational characteristics assigned. Subsequently, the simulation and energy analysis were performed with the REVIT add-on, INSIGHT into the cloud. Finally, the visualization and interaction with the results obtained on

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this platform were analysed through diagrams and performance diagrams directly in a virtual model.

Figure 4: Building energy in REVIT software

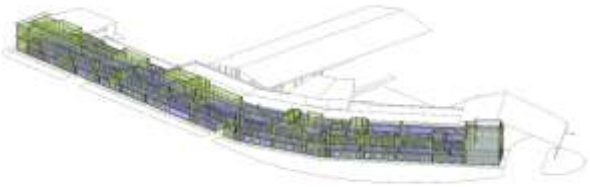

Figure 5: View of analytical spaces of the energy model of the building in REVIT software

The Energy Trend

Based on Figure 7, the highest peak demand is between 8am to 10am are due to many workers starting their work and active to do activity. Occupant users also produce heat and need more low temperature to coolest that area. If occupant or user increase use in that building, electricity demand also will be increased. It will affect energy performance all appliances are being used. During 2am until 6am no more occupant use electricity appliances. The reading still run with recorded 20.92 kWh which is for lighting and emergency light during night hour. After working hour 6pm and above also the reading is decrease from 67.35 kWh drop to 20.54 kWh. Assumption during weekdays, the highest is detected at time 10am which is more occupant is active to do their works. During afternoon, the heat temperature also increase which is need more coolest area.

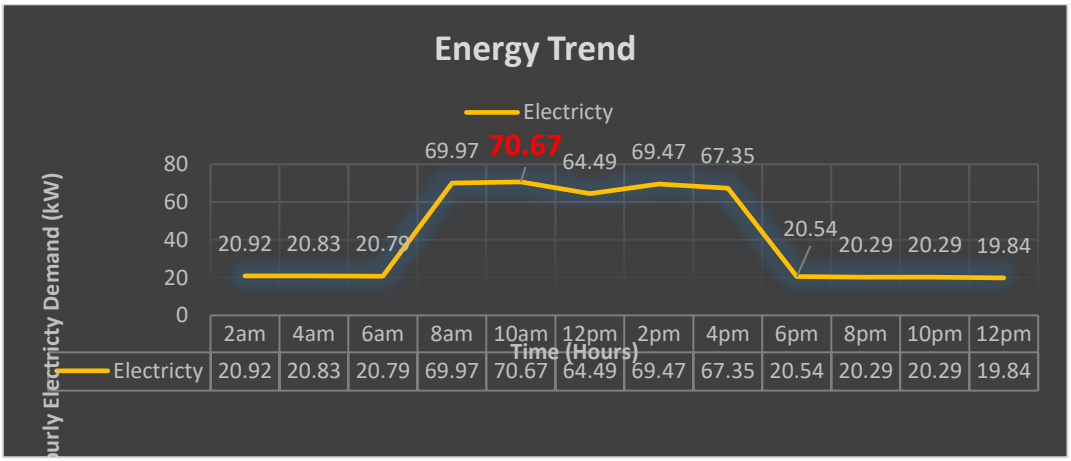

Figure 7: Energy Trend Electricity Demand (kWh) at Administration Building UiTM Tapah

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Limits of the Study

At this point, it should be noted that this study on energy simulation of buildings using a BIM model, while offering interesting results and ideas, is a simulation study and has the typical limitations of this type of study, among which, in our case, are the following:

i. Uncertainty regarding the results due to lack of measurement verification, as it is an old building that does not have appropriate counters that allow having real data.
ii. This research will not cover on the cooling aspect (air conditioning system) and all the related characteristic of thermal comfort, climatic and environmental aspect and weather records. It will also not cover on the impact of financial analysis on the retrofitting process.

Research Methodology

This document aims to study a working methodology in which using a BIM model of an existing administration building for public university use, a simulation of energy behaviour and energy analysis on this model can be carried out. To do this, the energy model of a building (BEM), which within the BIM methodology is known as BIM 6D was obtained (Milyutina, M.A, et. al., 2017). Through energy simulation, and after analysing the current energy state of the building, the aim was to study possible alternatives to improve energy efficiency, optimizing its sustainability (Radulovic, F., et. al., 2015) and to study improvement of energy performance in an existing administration building at UiTM Tapah through application of BIM. First, the architectural modelling of the building was carried out, and for this, the BIM REVIT software was used (Autodesk, 2020). With this software, the energy model was also obtained, with which the energy simulation and analysis were subsequently performed with the plug in for REVIT, INSIGHT 360. Through REVIT-INSIGHT 360 LIGHTING, and also through cloud calculations an analysis of lighting and natural light of the BIM model through automatic and customizable configurations for different types of study was carried out.

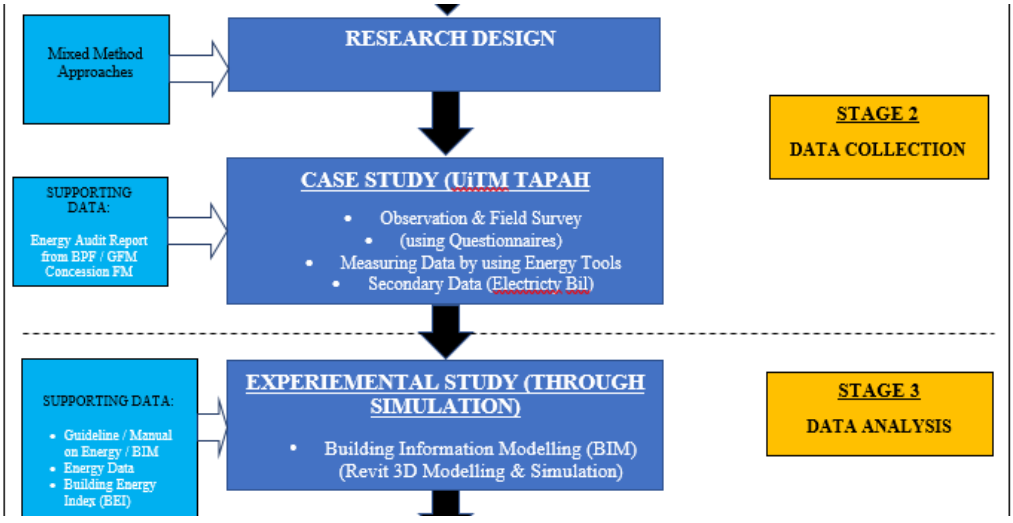

Figure 8: Research Framework

The Pilot Study

The pilot study has started from design variables. The data energy as shown as below: Measuring energy data through Electrical Appliances in the pilot study.

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Experimental Research Design: Mixed Method Approaches

The study is to focus on an electricity usage pattern of both academic and administrative buildings daily recorded over the period with one year for non-working days and working days for the administration buildings (Amber, *et. al.*, 2017). To achieved the main objective of this research, the experimental study will be used by using equipment tools on site for get the actual data and desktop study will be conducted to study the retrofit energy performance on existing building by using Building Information Modelling (BIM).

Stage of Data Collection

In this stage, the observation and site inspection for the case study of Admin Building UiTM Tapah will be performed. The questionnaires (to investigate the pattern of electricity usage) in the case study has been carried out at the site. The energy equipment for testing will also be used for recording the actual data energy usage condition at the case studies. The type of tools and equipment used is DATA Logger and ammeter for energy load profile. Questionnaire on survey form with staff or building occupant will be as an input on the supporting data. Other than that, an energy audit report from Development and Facility Management (BPPF) UiTM Tapah, 2018-2020 will be added as supporting data for this stage. The survey data form will be passing to building occupants and will be collected daily during standard working hours with five days per week.

Simulation on the Building Information Modelling (BIM)

In term of environmental assessment for sustainable building information modelling (BIM), the integration requires that product specific and energy related environmental profiles are available, for example, in the form of an XML database (Tarja, 2015).

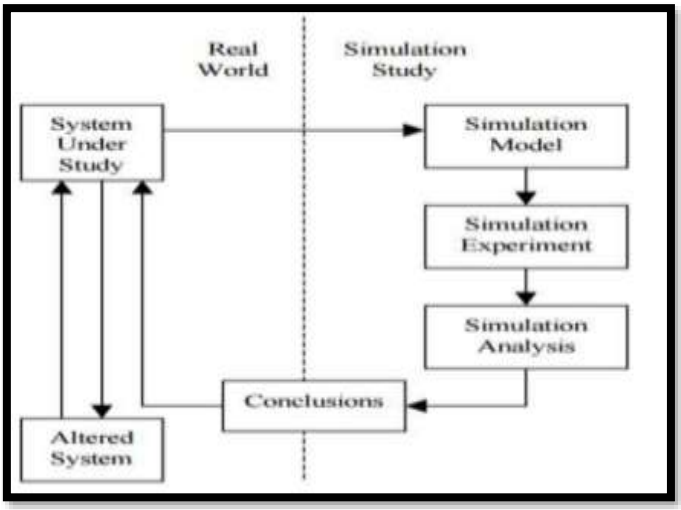

Figure 9: Simulation Study Schematic
(Sources: Hassan, 2016)

Simulation can be one tool used to examine possible scenarios that can be followed (Hassan, 2016) used to simulate everything from games to economic growth to engineering problems. Based on figure 9 above, it will explain that the process flow from on real world forward to simulation study process. After completed collect the data from actual condition, the next step will be conduct the process from provide the 3D model, simulation model, simulation experiment, simulation analysis and result or finding. In construction industry familiar with

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Building Information Modelling (BIM) the software has been to use is such as Microsoft Excel, Microsoft Project, Autodesk AutoCAD, Autodesk Revit, Autodesk Naviswork, while on sustainable energy simulation platform is Autodesk Ecotec, Integrated Environmental Solution (IES-VE), Autodesk Green Building Studio (GBS) Energy Plus, eQuest and others. Therefore, in this research, the preparation on Stage 3 (data analysis) desktop study will be running on this stage by using Autodesk Revit for 3D model and Autodesk Green Building Studio (GBS) and Insight has been used on this experimental research.

Results

First, the results obtained from the energy simulation of the Administration Building with the BIM software tool are presented. Subsequently, the behavior of the building from the energy and environmental point of view will also be optimized, also from the BIM software platform, studying the different possible improvement alternatives for the building studied in the discussion of the results section (Forcael, E., et. al., 2019).

Result Obtained in the Energy Simulation for All Possible Cases of the Building

Table 1: Lighting T5 without LED

Lighting T5 without LED

Location	Level Floor	Type of Light	Quantity	Power / Unit (Watt)	Total Power (kW)	Power Consumption / On Peak (kWh) (7.00am-10.00pm)	Power Consumption / Off Peak (kWh) (10.01pm-7.00am)	Total Energy	Cost "On Peak Hours" (RM0.3650)	Cost "On Peak Hours" (RM0.2260)	Bill Cost / Month (30 days)
Pentadbiran		T5 Tube 2ft	300	14	4.2	38	-	38	13.8348	-	276.70
		T5 Tube 4ft	183	28	5.124	46	-	46	16.83234	-	336.65
							Total (kWh)	84		Total (RM)	613.34

Table 2: Lighting T8 with LED

Lighting T8 with LED

Location	Level Floor	Type of Light	Quantity	Power / Unit (Watt)	Total Power (kW)	Power Consumption / On Peak (kWh) (7.00am-10.00pm)	Power Consumption / Off Peak (kWh) (10.01pm-7.00am)	Total Energy	Cost "On Peak Hours" (RM0.3650)	Cost "On Peak Hours" (RM0.2260)	Bill Cost / Month (30 days)
Pentadbiran		T8 Tube 2ft	300	10	3	27	-	27	9.882	-	197.64
		T8 Tube 4ft	183	16.5	3.0195	27	-	27	9.9196575	-	198.38
							Total (kWh)	54		Total (RM)	396.02

Table 3: Lighting Cost with and without LED

Lighting Cost with & without LED

Location	Level Floor	Type of Light	Quantity	Lighting Cost / unit (Lamp + Ballast) RM	Total Lighting Cost (Lamp + Ballast) RM	Total Lighting Cost (LED Lighting) RM	Lighting Cost / unit (LED Lighting) RM
Pentadbiran		T5 Tube 2ft	300	97	29100	25	7500
		T5 Tube 4ft	183	100	18300	28	5124
				Total (RM)	47400	Total (RM)	12624

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Table 4: Result Summary for Energy Consumption and Bill Payment Existing Lighting and LED including with Return on Investment (ROI)

	Energy Consumption (kWh/month)	Bill Payment (RM/month)	Energy Consumption (kWh/year)	Bill Payment (RM/year)
Existing	84	613.34	1008	7360.08
LED	54	396.02	648	4752.24
Difference (Comparison)	30	217.32	360	2607.84

Total Cost for Replace LED Lighting	: LED BULB LIGHT	
	: RM12,624.00	
Annual Profit	: Existing Total Payment - LED Total Payment	
	: RM7,360.08 - RM4,752.24	
	: RM2,607.84	
Payback Period / Return on Investment :	TOTAL COST	
	ANNUAL PROFIT	
:	12,624	
	2,607.84	
:	**4.8**	**Years**

As can be seen in Table 1, 2, 3 & 4 of the cases analysed for our building, we obtained:
• Maximum consumption (by using Lighting without LED): 1008 kWh/(m2 year);
• Minimum consumption (by using LED): 648 kWh/(m2 year);
• Difference consumption for both type of Lighting: 360 kWh/(m2 year).

At this point, it should be said that BIM software used, with the data from our building modelled in BIM, performs the simulation combining all the analysis factors, where each has a series of predefined values. It shows the results identifying two situations: the existing case and future case, estimating simulation which is replace for saving type of equipment lighting. Since the software can be used for both new or existing buildings, it analyses all the possibilities available.

Conclusion

In building and energy industry, it is familiar to used simulation with the adoption of Building Information Modelling (BIM). The research and development work carried out on BIM so far has had a significant focus on new buildings especially in Malaysia scenario. In BIM industry there are many types of dimension BIM. Nowadays, as we know that 3 Dimension (3D) has mastered from the 2 Dimension (2D) which is conventional method application. But in this research, 6 Dimension (6D) has been carried out for sustainability design. In BIM industry Malaysia, 6D less implication for use in the architectural, engineering and construction industries. For example, case study for this research is an education building administration. This administration building can be used as a trend example of use to other buildings that practice office hours of 8 hours a day and 5 days a week. Therefore, under the 6D implication, energy savings can also be simulated in this 6D stage. The energy saving simulation that is carried out is like converting traditional lights to LED lights. In conclusion, kWh consumption can be reduced as well as monthly bill payments can also be reduce.

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eISSN: 0128-1755
Journal website: www.jised.com

References

Aksamija, A. (2012). "BIM-based building performance analysis: Evaluation and simulation of design decisions." Proceedings of the 2012 ACEEE Summer Study on Energy Efficiency in Buildings

Aljundi K., Pinto A., Rodrigues F., 2016, "*Congress Portugese de Building Information Modelling*". Pp 309-319

Amber K.P., Aslam M.W., Mahmood A., Kousar A., Younis M.Y., Akbar B., Chaudhary G.Q., Hussain S.K., 2017, "Energy Consumption Forecasting for University Sector Buildings". Vol.10, Energies, pp1-18

AUTODESK ®. 2020. Available online: http://usa.autodesk.com/adsk/servlet/pc/index?site on 15th March 2021.

Biblus & ACCA Software, April 2018. BIM dimensions – 3D, 4D, 5D, 6D, 7D BIM explained. Retrieved from http://biblus.accasoftware.com/en/bim-dimensions-3d-4d-5d-6d-7d-bim-explained/ on 19th August 2018

Boton, C.; Kubicki, S.; Halin, G. The Challenge of Level of Development in 4D/BIM Simulation Across AEC Project Lifecyle. A Case Study. Proc. Procedia Eng. 2015, 123

David E., Blake S., 2011. BIM for Contractors: Autodesk® Navisworks® from Design to Construction to Facilities Management.Directive 2010/31/EU of The European Parliament and of The Council of 19 May 2010 on the energy performance of buildings (recast), Official Journal of European Communities, L 153, 18.06.2010, pp. 13- 35

Directive 2010/31/EU of The European Parliament and of The Council of 19 May 2010 on the energy performance of buildings (recast), Official Journal of European Communities, L 153, 18.06.2010, pp. 13- 35.

Doulos, L. Kontadakis A, Masias E.N, Sinou M, Tsangrasoulis A. Minimizing energy consumption for artificial lighting in a typical classroom of a Hellenic public school aiming for near Zero Energy Building using LED DC luminaires and daylight harvesting systems. Energy Build. 2019, 194, 201–217.

Dubois, M.-C. and Å. Bolsterer (2011). "Energy saving potential and strategies for electric lighting in future North European, low energy office buildings: A literature review." Energy and Buildings 43(10): 2572-2582.

Forcael, E.; Nope, A.; García-Alvarado, R.; Bobadilla, A.; Rubio-Bellido, C. Architectural and Management Strategies for The Design, Construction and Operation of Energy Efficient and Intelligent Primary Care Centers in Chile. Sustainability 2019, 11, 464.

Gao, H., Koch, C., & Wu, Y. (2019). Building information modelling based building energy modelling: A review. Applied Energy, 238 (December 2018), 320-343

Ghaffarianhoseini. A., Tookey. J., Ghaffarianhoseini. A., Naismith. N., Azhar. S., Efimova. O., Raahemifar K., 2016. Building Information Modelling (BIM) uptake: Clear Benefits, understanding its implementation, risks and challenges. pp.1046-1053

Hassan N.A., 2016. Green BIM Software. Building Energy Simulation. Retrieved from slide share https://www.slideshare.net/naghamahasan/green-bim-software-dr-nagham-ali-hasan on 19th August 2018

Miettinen R., Paavola S., 2014. Beyond the BIM utopia: Approaches to the development and implementation of Building Information Modelling. Autom Constr 2014; 43 pp.84-91

Milyutina, M.A.; Mohammad, W.N.S.W.; Abdullah, M. Application of 6D Building Information Model (6D BIM) for Business-storage Building in Slovenia. In Proceedings of the World Multidisciplinary Civil Engineering-Architecture-Urban Planning Symposium—WMCAUS Autoría Conjunta del Libro: IOP Colección: IOP Conference

Series-Materials Science and Engineering; IOP Publishing Ltd.: Prague, Czech Republic, 2017; Volume 1, pp. 202–210

Mohammad N.L., 2000, "Exploiting BIM in Energy-Driven Renovation and Retrofitting: A Paradigm of Future Opportunities". *Bahagian Rekabentuk Fasiliti Pendidikan Tinggi, Cawangan Arkitek Ibu Pejabat JKR Malaysia*

Radulovic, F.; Poveda-Villalón, M.; Vila-Suero, D.; Rodríguez-Doncel, V.; García-Castro, R.; Gomez-Perez, A. Guidelines for Linked Data generation and publication: An example in building energy consumption. Autom. Constr. 2015, 57, 178–187.

Suermann P., 2009. Evaluating industry preception of building information modelling (BIM) impact on construction. International Journal of IT in construction. 14:574-594.

Tarja H., 2015. Sustainable Building and BIM. Technical Research Centre of Finland