SEMARAK ILMU PUBLISHING

Journal of Advanced Research in Fluid Mechanics and Thermal Sciences

Journal homepage:
https://semarakilmu.com.my/journals/index.php/applied_sciences_eng_tech/index
ISSN: 2462-1943

BIM-Based Building Performance Analysis for a Green Resort in Malaysia

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ARTICLE INFO

Article history:
Received 11 September 2022
Received in revised form 17 Nov. 2022
Accepted 21 November 2022
Available online 30 November 2022

Keywords:
Building information modelling; BIM; energy analysis; hospitality-based building; revit

ABSTRACT

Building Information Modelling or BIM has proved its competency in making build construction process effective and efficient. Due to the emergence of more energy efficient approaches and popularity of green certification in building construction, BIM also became a valuable tool to evaluate the building energy performance and sustainability level. Various building typologies using green approaches started to emerge due to the Malaysia Government's sustainability and green policy according to the 2009 National Green Technology Policy (NGTP). Although this development includes green hotels and resorts but there is still lack of quantitative analysis for existing tourism facilities in Malaysia, specifically for green resorts. Thus, this paper describes through literature studies the current BIM development and issues in Malaysia, the green resort certification, and its challenges, as well as the general energy consumption of a hospitality building in Malaysia. By using the BIM-based simulation, this paper is an attempt to investigate the building performance analysis in terms of energy and cost in relation to hospitality industry building design specifically a green resort in Malaysian context. Design alternatives for the existing selected green resort facade were also proposed to further demonstrate the usefulness of BIM simulation to choose the best design option that is energy-cost effective. The conclusion explained the research limitations of the project and indicates the results can be perceived faster by using the simulation as it demonstrated that even the smallest changes can give a positive effect energy-wise and cost-wise which proved that it is beneficial to construct a green resort in the long run.

1. Introduction

Building Information Modelling (BIM) advancement includes the ability to evaluate the building energy performance to comply with the Standards of Green Building Practice. Ebrahim and Wayal [1] stated that in the construction industry, the construction of buildings with green certification and sustainable practices has become significant as the Green Building evaluation was recognized in the practice. With the introduction of the 2009 National Green Technology Policy (NGTP) by the Malaysian Government as a part of the country's sustainability and green policy, a lot of industries

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https://doi.org/10.37934/araset.28.3.320335

were influenced to adhere to the policy as there are incentives given [2]. As a result of this, many existing buildings in Malaysia now strive to get certification as green buildings. These can be achieved easily by newer buildings that took advantage of BIM to make effective decisions in the earlier design stages. However, the impact of this approach is still not optimal [3-6] since the existing building stock, majorly consisting of buildings with years and even decades of existence have a higher numerical percentage than the newly developed green building [7-8].

The same can be said with the hospitality industry as according to Peršić-Živadinov [9] there should be the incorporation of the concept of green and sustainability in the industry. The top individual or associated chain resorts and hotels started to involve themselves in the green hospitality industry in the 90s [10] mainly due to the financial benefit as it can save a lot in terms of energy usage, water usage and waste management. For example, the Shangri-La Group in their 2019 Sustainability Report [11] has mentioned that their energy, water, and carbon intensity has declined by 10.0%, 3.6% and 8.9% respectively from 2015 until 2019. Successively, the trend in domestic and international tourism also places importance on environmental-friendly approaches and sustainability where eco-tourism was strongly linked with the resort industry. Therefore, becoming a green hotel or resort means there will be added positive value to the hospitality building as it usually puts the building or a brand into the limelight.

Although most of the Green Hotel requirements involves the management aspect for energy-saving, reducing water consumption, and reduction of waste products measures, existing hotels/resorts retrofitted their building to achieve this goal by implementing renewable energy programs (i.e., solar and wind power), installing energy-efficient appliances and equipment, controlling guestroom energy consumption by using digital thermostats, use of Energy Star-qualified products, installation of lighting motion sensors in low-traffic areas, installation of triple-glazed windows or reflective glass, using energy-efficient light bulbs (LED) and depending on passive lighting for housekeeping [12]. This can be done by having a comprehensive analysis to determine which part need optimization to improve the building's performance during its lifecycle.

In this case, BIM tools can especially be used to provide energy analysis as it can do the Building Performance Analysis (BPA) by testing, analyzing, and analyzing the building design. Energy analysis tools such as Ecotect, Green Building Studio (GBS), and Insight are used in parallel with BIM software such as REVIT, ArchiCAD, and Bentley. Thus, this study aims to develop the optimization scenarios of the design features that can improve the economic performance of a selected green resort evidenced by the usage of Building Information Modelling software as there is still a lack of quantitative analysis for such tourism facilities in Malaysia. This study will mainly focus on the cost saving that can be generated from different building properties and their energy usage. The study will also compare the Conventional Resort Model and the existing Green Resort Model. Lastly, several design alternatives to improve the existing green resort condition will be presented and analyzed in GBS.

1.1 BIM in Malaysian Context

Building Information Modelling (BIM) is an intelligent tool that can maximize the efficiency of a project from inception until completion. It contains an integrated digitalized model with relevant information for the stakeholders in the Architecture, Engineering, and Construction (AEC) sector. It has vast applications and involves the integration between all the stakeholders in terms of project management, design of structural components, or asset management for the period of the building lifecycle. According to CIDB [13], better performance can be achieved, efficacy can be enhanced the productivity and quality of construction as well are some advantages that can be achieved by using BIM. Thus, through Construction Industry Transformation Programme (CITP) 2016–2020, Malaysia has also planned a strategic approach to BIM implementation in the Malaysian construction industry to follow the global digital construction progress [14].

Currently, BIM development and implementation in Malaysia is mandated to CIDB since 2011 by the Malaysian Government [15]. Cooperation between the public and private sectors of Malaysia has nurtured BIM development in Malaysia through numerous approaches. For example, the Minister of Works through the Malaysian Construction Industry Development Board (CIDB) and construction industry stakeholders developed the Construction 4.0 Strategic Plan (2021-2025) to accommodate the global digital revolution or commonly known as Industrial Revolution 4.0. [16]. CIDB 2019 Building Information Modelling (BIM) Report has listed the comprehensive development of BIM in the Malaysian context through their surveys by taking all industry key- players' opinions and involvement into consideration [17].

Although there are challenges in BIM implementation in Malaysia, the awareness of BIM among the respondents of a survey made up of industry personnel has increased by 29% since 2016 according to the 2019 CIDB BIM Report. The gigantic corporation recorded the highest number in BIM adoption among all that contributing to 49% of BIM implementation nationwide. This upwards trend was significant with a more than 30% increase in BIM adoption as compared to the previous report. In addition, more than half of the involved organization has a clear BIM implementation policy and applied coordination of the BIM model among project stakeholders while 43% of them have allocated budgets for BIM implementation and 40% possessed high assurance in terms of their BIM knowledge and skills [17]. Following the BIM implementation outline by CIDB, BIM in Malaysia was to be used in the entire building lifecycle [18] which includes design, construction, as-built stage, and maintenance.

Despite the positive outlook, a recent study [19] shows that the implementation of BIM in Malaysia was not done completely since it only covers the production of the BIM model whereas there is also inefficiency in BIM implementation for the whole BIM project management. Wan Mohammad [20] quoted that despite the many numbers of workshops regarding BIM adoption done for Contractors from various classes by CIDB, they are not aware of the number of those who have implemented BIM in their projects and there is still a lack of definite direction on how to implement BIM for the construction organization after attending the said sessions. Thus, the Malaysian stakeholders' BIM competency might be questionable since rather than implementing the whole BIM technology comprehensively, some of the organizations chose to outsource their BIM works [21].

In summary, it is noteworthy that BIM implementation in Malaysia has a positive prospect as the BIM adoption rate and awareness rate has improved considerably in the span of three years. Although it was still lower if compared to the United Kingdom (UK) which has a 69% adoption rate in 2019, it was because they have mandated earlier BIM implementation. Subsequently, the Malaysian Ministry of Works through the Public Works Department (JKR) Strategic Plan 2021-2025 also has set the BIM adaption in the construction industry to reach 80% by 2025 [22]. With the application of Autodesk REVIT software as the main operational software by the Public Works Department itself, it will be just a matter of time until it became the main software used in the construction industry due to its ability to cross-platform easily. Only with cooperation and effort from all related stakeholders of the construction industry, BIM implementation in Malaysia can reach 100% of its potential.

1.2 Green Hotel Standards and Practice

Green Hotel is a hotel that is environmentally friendly and adopts energy conservation measures. A Green Hotel as defined by ASEAN Green Hotel Standard [23] is "an establishment for the promotion of Environmentally friendly and Energy Conservation." It involves all departments of the establishment such as engineering, housekeeping, administration, and facilities department. The standards cover a comprehensive approach to a Green Hotel by including clearly defined terms, providing a checklist of procedural requirements and comprehensive criteria to be adhered to. There are eleven major criteria to be followed as shown in Figure 1.

Fig. 1. ASEAN Green Hotel Standard Guidelines (ASEAN, n.d.)

The ASEAN Green Hotel Awards which is a part ASEAN Tourism Standard Awards will be awarded to the hotel or resort that has the highest abiding values. As of today, the Malaysian Ministry of Tourism, Arts and Culture has listed thirteen hotels that have been awarded the triennial ASEAN Green Hotel Awards [24] which are mostly retrofitted to comply with the ASEAN Green Hotel Standards. These standards, however, comprise a qualitative checklist. Hence, there is still a lack of quantitative analysis about green approaches and sustainability for existing tourism facilities in Malaysia which this study hoped to rectify.

1.3 Hospitality Building Energy Consumption

Kasim [25] and Bohdanowicz [26] agreed that one of the sectors that cause environmental degradation is the hotel sector as it causes various kinds of pollution such as water, energy, and waste pollution. Bohdanowicz added that annually, a hotel can produce between 160 and 200kg of CO_2 per square meter of the room. Moorthy and Yacob's studies [27] also showed waste material resources as a significant contributor to hotel environmental pollution. Later, Polat [28] also listed those accommodations, including those from the tourism sector are significant contributors to climate change through CO_2 emissions from the visitors. Moreover, construction for tourism facilities often implicates the site and its surroundings which might cause negative environmental effects on the natural landscape. Locally, Chand *et al.*, through their study [29] on a resort building that focused on the three end-user groups (Air-conditioning, electrical appliances, and hot water generation) found out that air conditioning has the highest energy consumption ranging from 56.2% to 72.4% monthly. Instead, water heating consumes the least electrical energy ranging from 9.1% to 13.2% monthly energy consumption. The electrical appliances, specifically in the restaurant also showed a high percentage of total annual energy consumption due to the high number of refrigerators and freezers which can consume approximately 15kWh of energy per day during the non-operating day but still less than the air conditioning. This is in lieu of the typical hotel energy distribution [30] as shown in Figure 2.

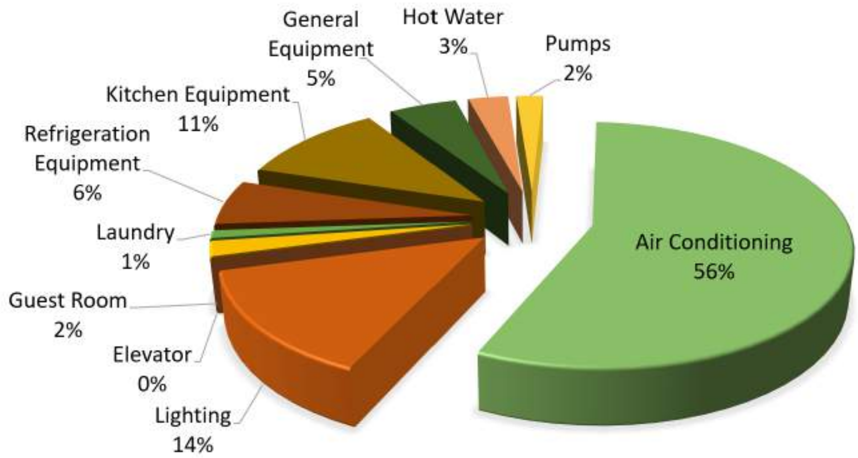


Fig. 2. Typical Hotel Energy Distribution

Energy consumption in a hospitality-based building is high due to the multi-layered building services operation. Different energy characteristics defined different functional areas in addition to 24 hours energy usage and diversity in the needs of customers. As specified by Abdu Bakori *et al*., [31], hotel sectors were made up of a lot of departments such as housekeeping, food and beverage production and amenities, laundry facilities, guest rooms, and conference facilities; all consumed a lot of energy from HVAC, lighting, and other equipment. Shao *et al*., [32] stated that most of the research on energy usage revolves around office and commercial buildings while the research on hotels' energy usage is still relatively minor in number due to its complex energy usage. In terms of water management, Ahmed *et al.*,[33] also listed water conservation measures implemented by the hotel sector in terms of reducing water consumption and management. These include water-efficient devices and appliance retrofitting such as low-flow toilets, low-flow showerheads, and infrared-activated faucets. Towel/bed linen recycling programs are also done, leaks in toilets and baths are regularly checked and fixed, grass and plant watering are done early in the morning and late at night, and the grey water is recycled for grass irrigation. Each department has water consumption monitoring to track the usage.

Although in recent years, there are an increase in the research done about hospitality-based building performance internationally, its scarcity in the hot and humid Malaysian context is still prevalent. Some of these studies showed that the typical subtropical climate of Malaysia is the major cause of the increase in consumption of electrical energy as it also increases thermal comfort needs while one of the main sources used to generate electricity is by using fossil fuels. [34-35]. In addition, Shaikh *et al*., [36] suggested that based on their evidence, residential and commercial sectors buildings in Malaysia consume roughly 14.3% of total energy and where 53% of it is for electrical energy. As hotels and resorts fell under the category of a commercial building, we can deduce that it also consumes roughly the same amount of energy or more especially because they have 24 hours operation.

2. Methodology

This research mainly utilizes a series of simulation using a BIM software to study the relationship between all the variables and the resulting building energy cost. The methodology also involved an on-site observation of the Green Building selected for the study. The author decided to focus on the Shangri-La Rasa Sayang Resort located in Batu Feringghi, Pulau Pinang which had received the ASEAN Green Hotel Awards for consecutive six years. This award is the highest award given to hotel or hospitality buildings in the Asian region following the strict Green Hotel standards as discussed in the literature review. Because of the large building scale, only one portion of the building (Garden Wing) as shown in Figure 3 which consists of resort rooms and restaurants will be used as part of the research. The initial data is collected through exploration and observation in form of building plans and materials used.

Fig. 3. Garden Wing of Shangri- La Rasa Sayang Resort

This research mainly uses BIM software, Autodesk REVIT Architecture 2020 as it is one of the main software being used in the current AEC industry in Malaysia. This software was used to build the building models. Depending on the data gathered, the design and documentation of building models can be easily updated, making them fast and reliable. The software used for energy analysis is Green Building Studio (GBS) which is linked to REVIT through Autodesk Insight. It is an adaptable simulation engine that can simulate the energy analysis, the cost, and the carbon footprint of a building as well as the lighting analysis and solar analysis. However, this research will be focusing on energy and water usage in terms of cost. Based on the data collected, the parameter used for the BIM model is finalized and tabulated in Table 1 before being inputted into the BIM models created respectively.

Table 1
Model Input Parameters for Conventional Model and Green Model analysis

Model Input	Conventional Model	Green Model
Parameter	Batu Feringghi, Penang	Batu Feringghi, Penang
Location	Hot and humid Climate Zone; ASHRAE climatic zone 1A	Hot and humid Climate Zone; ASHRAE climatic zone 1A
Weather	110mm thk. Brick Wall with 20mm thk. plaster and paint both sides	Hot and humid Climate Zone; ASHRAE climatic zone 1A
External wall construction	No insulation	110mm thk. Brick Wall with 20mm thk. plaster and paint both sides. No insulation
Roof	RCC Roof slab provided; No Insulation U value = 2.5 W/m2 K	RCC Roof slab provided with Insulation. U value = 2.5 W/m2 K Green roof is provided. U value = 0.37 W/m2 K
Glazing	Single Glazing	Double Glazing with tinted surface
Window to wall ratio	50% (Northwest and Southeast) 20% (North and South)	50% (Northwest and Southeast) 20% (North and South)
Floor Slab	Uninsulated	Uninsulated
HVAC System	Single unit air conditioning	Central VAV, HW Heat, Chiller 5.96 COP, Boilers 84.5 eff
Shading Device	No	Wooden screen

Based on the parameters in Table 1, two BIM models are created. The first one, labelled as the conventional model is the model where the parameters are entered according to the assumption of typical materials, finishes, and systems used without any green measures adopted. The second model labelled as a green model is keyed in with the parameters set to be as close as possible to the existing green resort condition. Net-zero measures such as the usage of green roofing, rainwater harvesting, vegetation by using a native plantation, and Grey-water reclamation. Generally, both models have the same appearance but are equipped with different thermal properties based on the material used. Figure 4 shows the BIM model of the selected case study in Autodesk Revit.

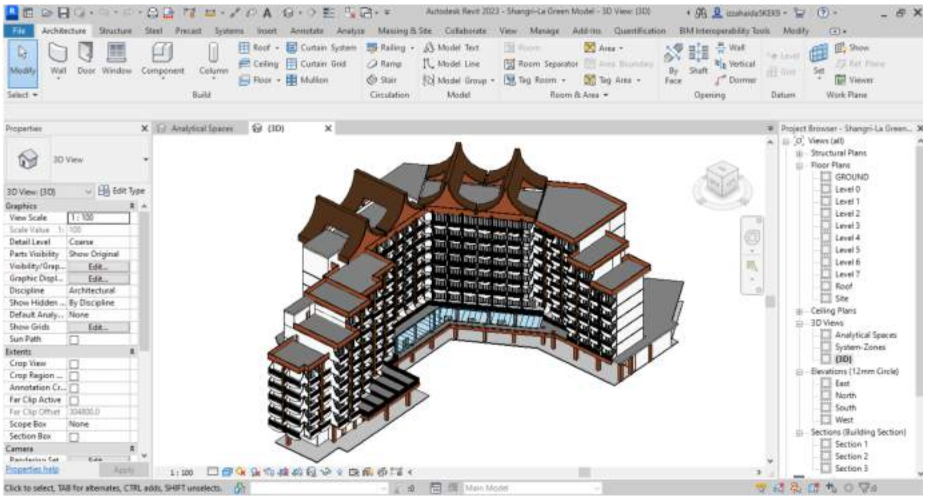


Fig. 4. BIM model of selected case study built in Revit

2.1 Creating Energy Model

To enable energy analysis, an energy model must be generated. Firstly, the building spaces and their properties as well as the HVAC zone depending on the type of room and their usage must be designated as shown in Figure 5 and Figure 6. Spaces designated will be included into the simulation calculation.

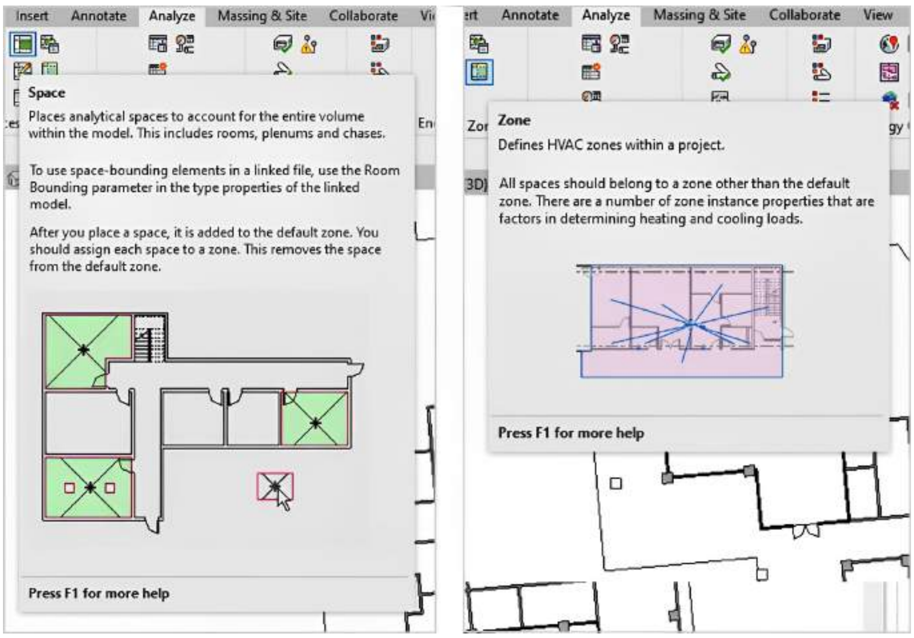


Fig. 5. Designating spaces and zones of the models

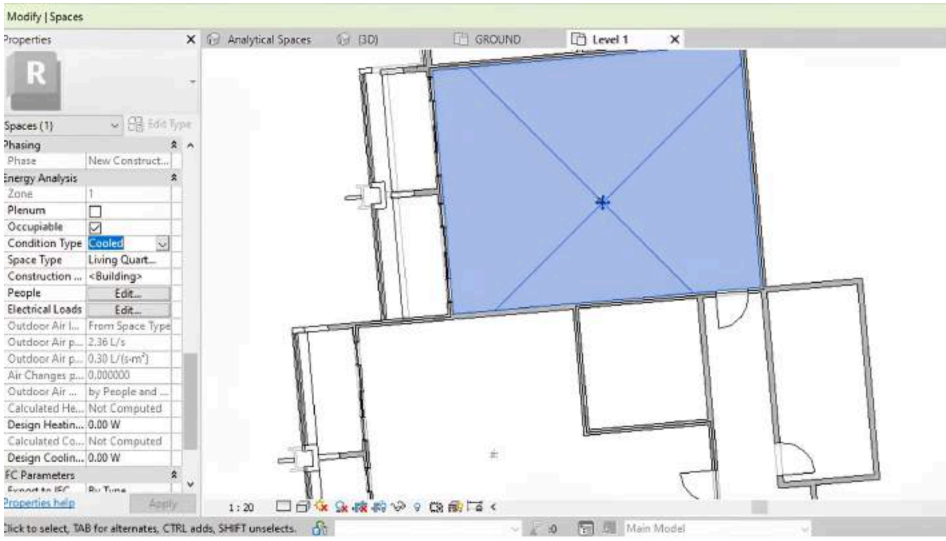


Fig. 6. Designating spaces and zones of the models

Next, it is important to define the energy settings before the energy model can be generated. The energy settings can be found on the 'Analyze' tab in the Energy Optimization section. The energy settings include a lot of options which are selected accordingly depending on the built BIM Model. Figure 7 shows the typical steps of energy settings. The most important thing is to designate the building type as it will automatically include default values for the simulation later. Both the Conventional and Green energy model was then generated by adopting the option "conceptual masses and building elements". The energy models as shown in figure 8 are then exported into gbXML format into Green Building Studio (GBS) cloud server for building energy, costs, and water usage analysis through the simulation.

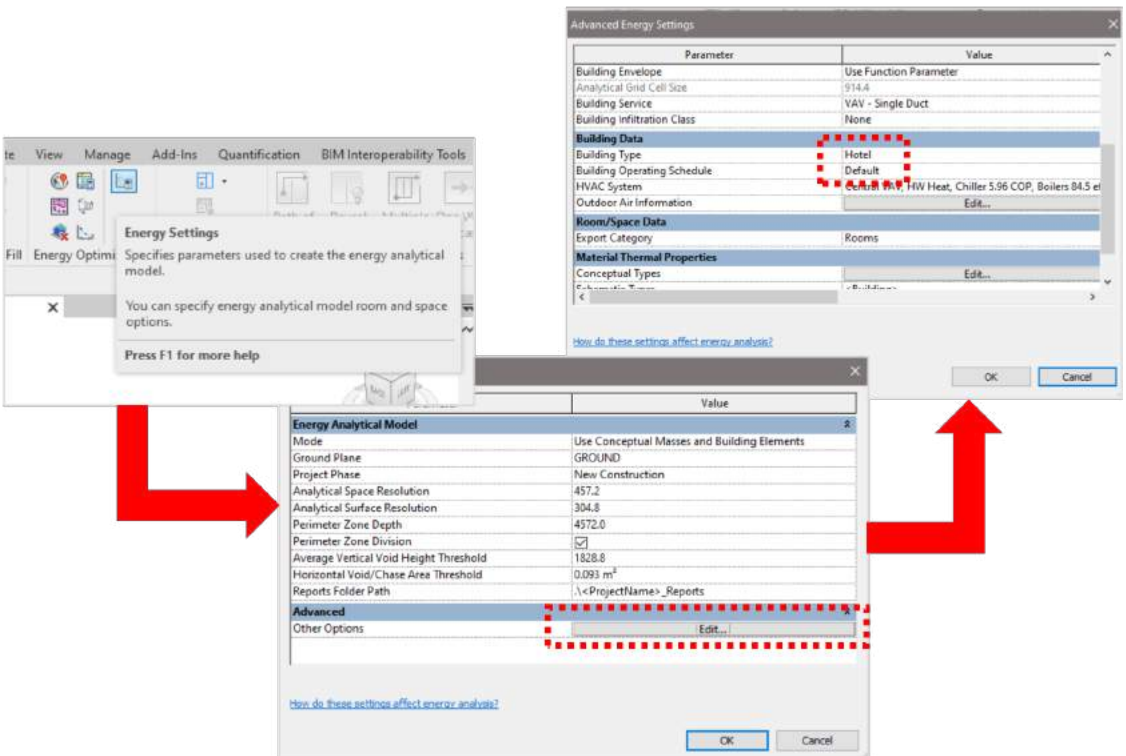


Fig. 7. Energy Settings

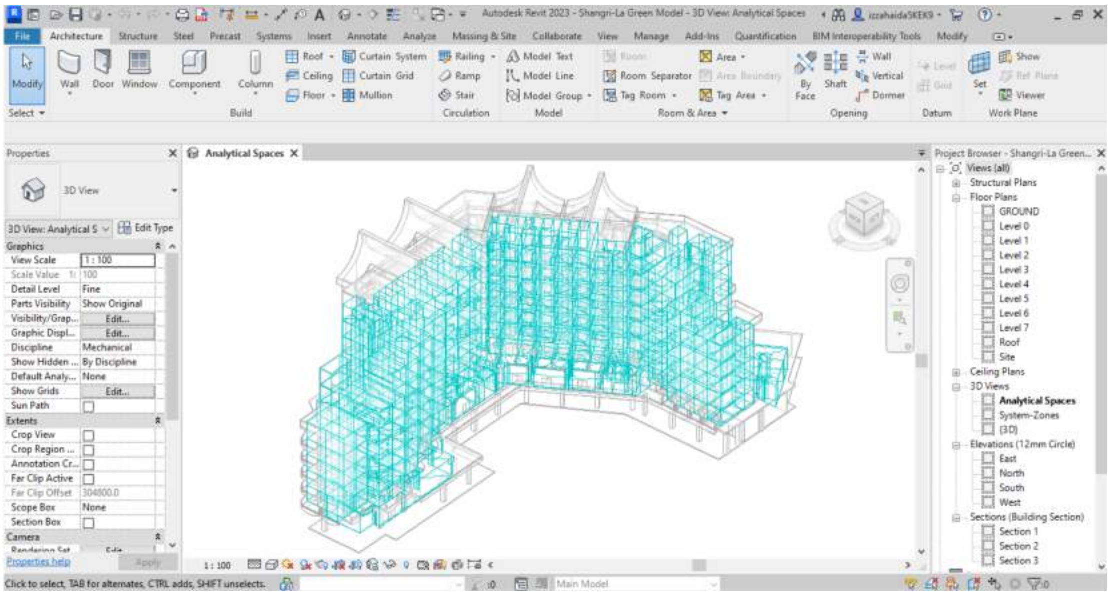


Fig. 8. Energy model created after energy settings

2.2 Green Building Studio (GBS) Energy Analysis

Green Building Studio (GBS) can be accessed through a web browser. To use the features, the user needs to have an Autodesk account. After login, a new project was created and the project basic information such as the project name, the facility type, its operating schedule, location, currency, weather station, and time zone are filled. Utility rates for this research will be using the GBS default value as shown in Figure 9. As this research is focusing on the Malaysian context, the result will later be converted manually into Malaysian Currency (RM). The exported gbXML file format will be analyzed as soon as it finished uploading into the GBS server and the results will be displayed in the GBS window as the base run result.

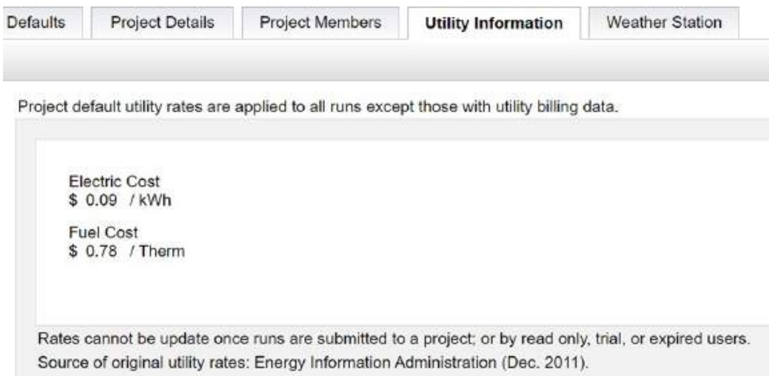
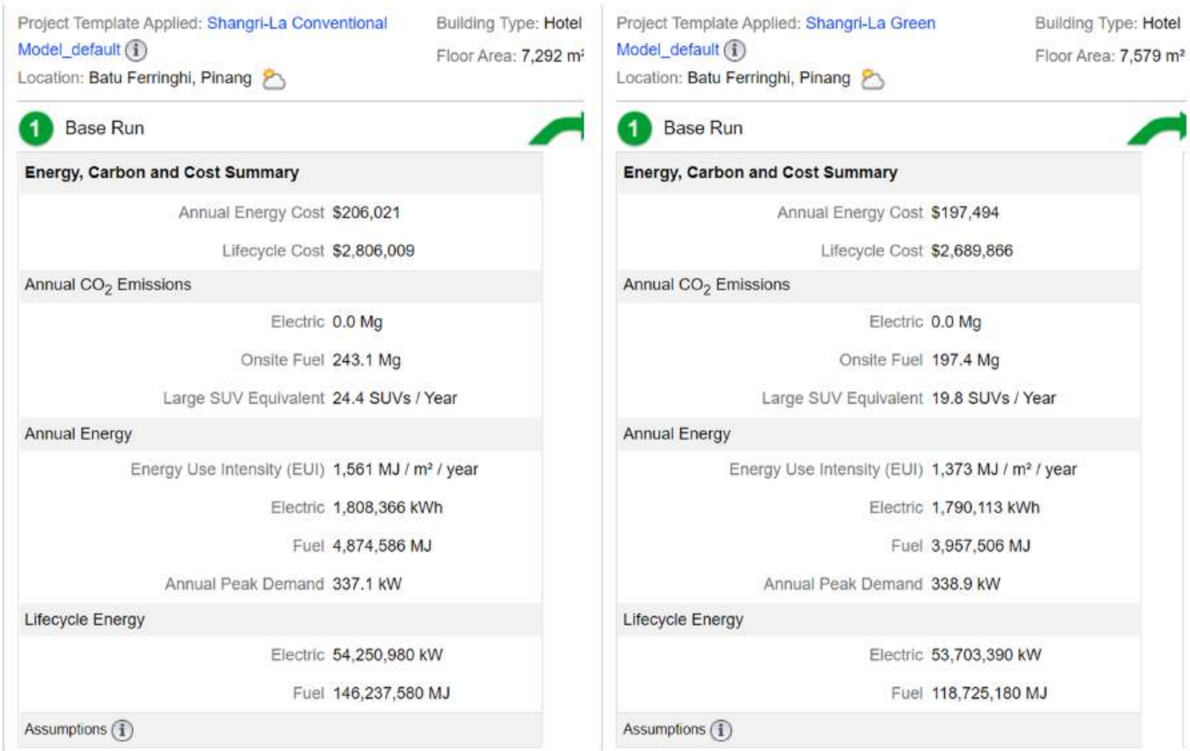


Fig 9. GBS Default value used for the studies

Name	Date	User Name	Floor Area (m²)	Energy Use Intensity (MJ/m²/year)	Electric Cost (/kWh)	Fuel Cost (/MJ)	Total Annual Cost [1] Electric	Total Annual Cost [1] Fuel	Total Annual Cost [1] Energy	Total Annual Energy [1] Electric (kWh)	Total Annual Energy [1] Fuel (MJ)	Carbon Emissions (Mg)	Compare	Potential Energy Savings
Project Default Utility Rates											Weather Data: GBS_06M12_12_335005			
Project Default Utility Rates	--	--	--	--	$0.09	$0.007	--	--	--	--	--	--		
Base Run														
Shangri-La Conventional Model	6/30/2022 3:39 AM	izzahaida5KEK9	7,292	1,561.2	$0.09	$0.007	$169,806	$36,208	$206,014	1,808,366	4,874,586	--		
Shangri-La Green Model	6/30/2022 3:43 AM	izzahaida5KEK9	7,579	1,372.5	$0.09	$0.007	$168,092	$29,396	$197,488	1,790,113	3,957,506	--		

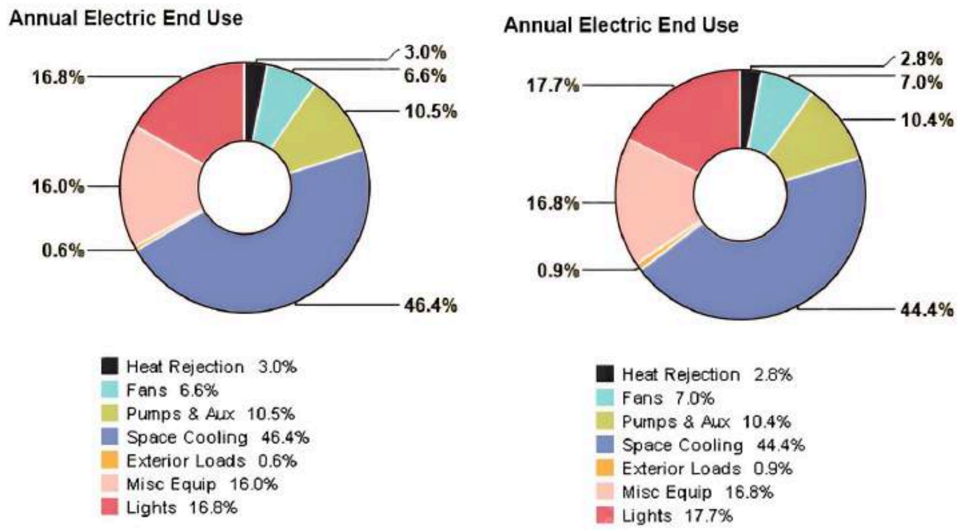
Fig. 10. Summary of comparison between Conventional Resort Model & Green Resort Model Base Run Analysis result



(a) (b)

Fig. 11. (a) Conventional Resort Base Run Analysis Result (b) Green Resort Base Run Analysis Result

The data obtained from the base run as shown in Figure 10 and Figure 11 compared the summary of annual energy intensity in the measure of fuel cost and the floor area as well as the annual cost of electricity, annual energy costs, and annual energy consumption for the conventional resort and the green resort. More detailed information as shown in the figure below can be obtained by clicking the model's name. Besides that, the energy end-use distribution as shown in Figure 12, and the water usage and cost estimation as shown in figure 13 can also be identified and analyzed. For the water usage estimator, to get more precise data, rather than using the default value set by GBS, the number of toilets, estimated users, and toilet settings as well as net zero measure was entered accordingly.



(a) (b)

Fig. 12. Typical Resort Model Energy Usage Distribution of (a) Conventional Model and (b) Green Model

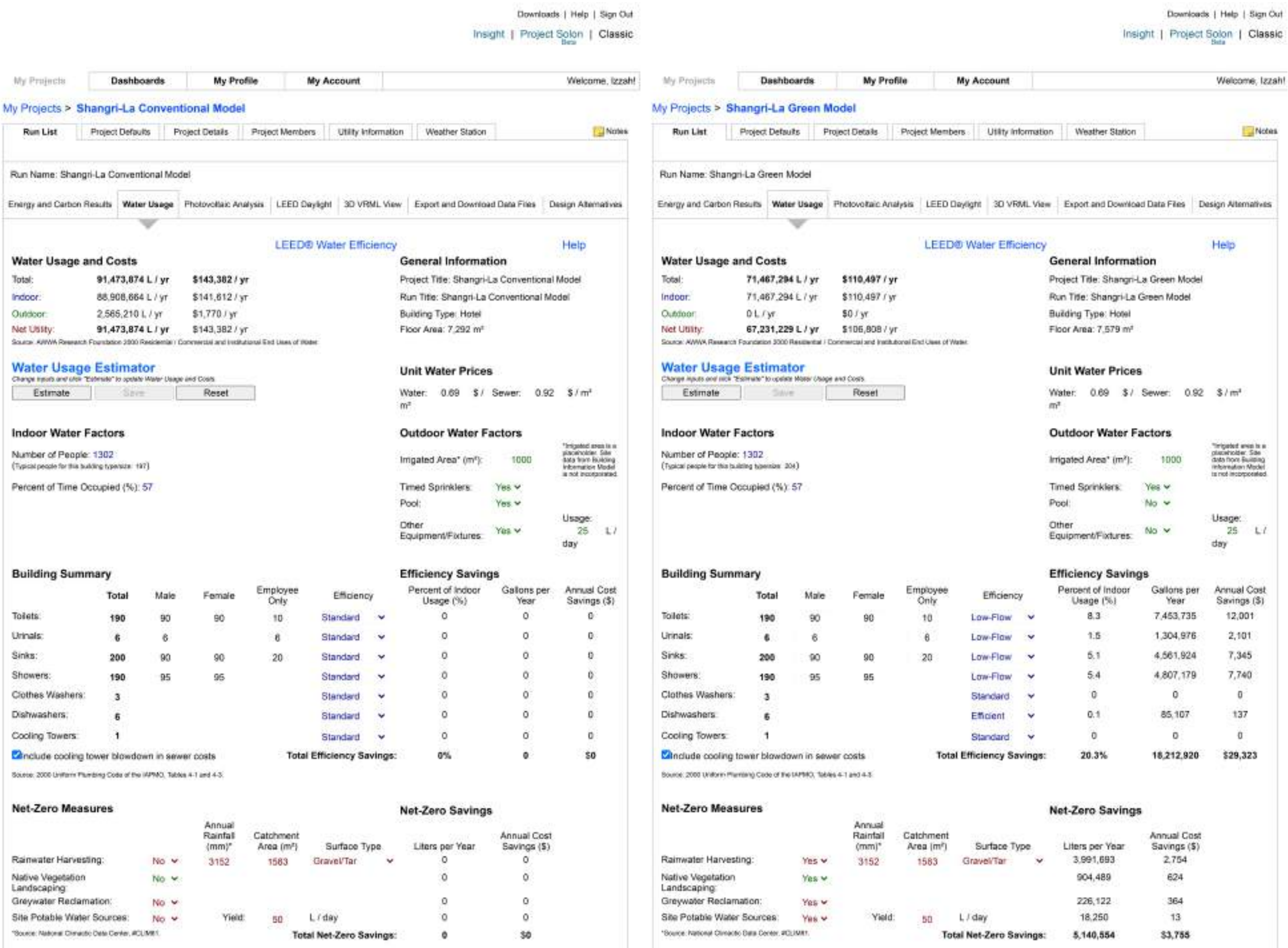


Fig. 13. Water usage estimation for (Left) Conventional Model and (Right) Green Model

3. Results and Discussion

Building Performance Analyses that have been conducted for the Conventional Resort model and the Green Resort Model showed that there is about 4% savings in Annual Energy Costs for the green resort rather than the Conventional Resort amounting to almost RM 37,700 and this is without any additional energy saving measures such as the use of renewable energy and energy saving features as shown in Figure 11. The other energy values such as the annual carbon dioxide emission, annual energy use intensity, and energy lifecycle also showed comparatively lower values for the green resort than the conventional resort.

As for the resort energy distribution, from Figure 12 we can see that the energy distribution followed the typical energy distribution for a hotel or resort building typology as reported in the literature review. In addition to that, we can see a 21% decrease in water usage and 23% of its cost respectively for the Green Resort Model compared to the Conventional Resort Model. With the addition of net zero measures such as rainwater harvesting, vegetation by using native plantation, and Grey-water reclamation to the Green Resort Model, it managed to reduce the net water consumption in litre by another 6% amounting to $3689 or RM16,298 annually. Thus, the research proves that the existing green resort gave significant savings compared to the Conventional Resort in terms of energy costs, energy consumption and water usage which can lower the overall resort operational cost.

3.1 Design Alternatives

To demonstrate further the usage of BIM for building performance analysis, three design alternatives were generated by using the existing Green Model. They were simulated in GBS 'Design Alternative' option to suggest design optimization in terms of annual cost by adjusting the building model parameters. The parameters are divided into seven categories: -

1. General (Building Rotation, HVAC, Outside Air Values, Infiltration, Occupancy)
2. Lighting (Efficiency, Control, Equipment & Light Power Density, Number of People, Occupancy, Daylighting Control and Sensor)
3. Roof (Construction)
4. Northern Walls (Construction, Glazing type,
Shade, Window to Wall Ratio)

5. Southern Walls (Construction, Glazing type, Shade, Window to Wall Ratio)
6. Western Walls (Construction, Glazing type, Shade, Window to Wall Ratio)
7. Eastern Walls (Construction, Glazing type, Shade, Window to Wall Ratio)

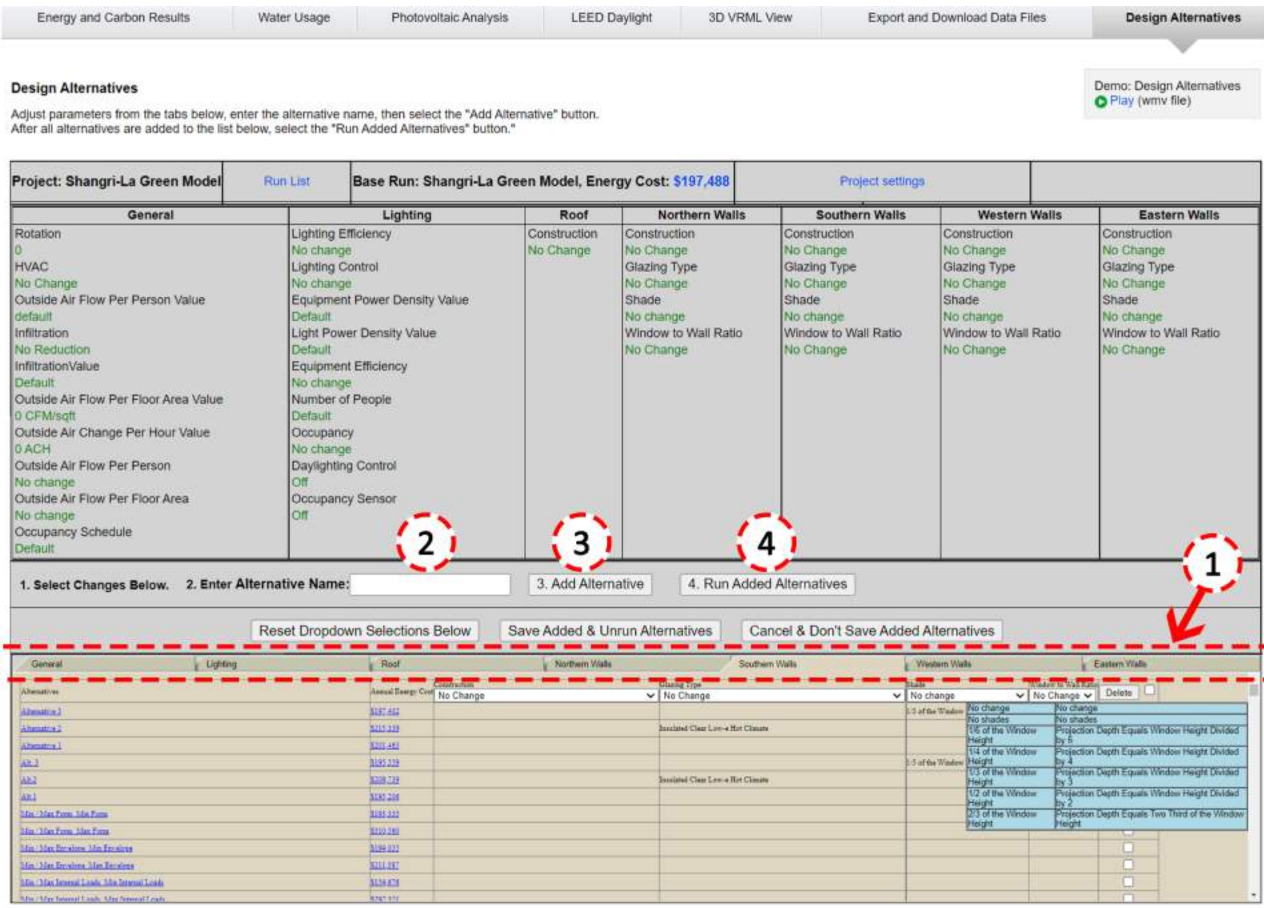


Fig. 14. Design Alternatives Run

These parameters can be changed by selecting the available design options provided. Figure 14 showed the parameter window and steps taken to prepare the design alternatives before running the new simulation for each of the scenarios. Firstly, a new alternative name needs to be entered. For this study, the alternatives are named "Alt. 1", "Alt. 2" and "Alt. 3" subsequently. The parameters that will be changed will be selected by using the drop-down options as shown in Figure 2, step 2. The alternatives then can be added to the run list by clicking the Add Alternatives button and lastly, they can be run simultaneously by clicking the Run added alternatives. These runs are considered as Design Alternatives Run, and their results can easily be compared with the Base Run results.

The three scenarios involved the building lighting control and openings of the model and the parameters changed are as shown in Table 2. The simulation results of each of the alternatives are recorded and compared with the Green Resort Model. The results in terms of cost can be compared easily by selecting the 'compare' icon as shown in the red region in Figure 15 and the result of the design alternatives comparison is shown in Figure 16.

Table 2
List of adjusted Parameters According to Design Alternatives (Alt.)

Alt.	Lighting control	Window to Wall Ratio	Glazing	Shading
1	Occupancy/Daylighting sensors & controls added	North and South: 50% East and West: 30%	No	No
2	Occupancy/Daylighting sensors & controls added	North and South: 50% East and West: 50%	Yes Insulated Clear Low-e Hot Climate	No
3	Occupancy/Daylighting sensors & controls added	North and South: 50% East and West: 50%	No	Yes 1/3 of window height

Name	Date	User Name	Floor Area (m²)	Energy Use Intensity (MJ/m²/year)	Electric Cost (/kWh)	Fuel Cost (/MJ)	Total Annual Cost [1] Electric	Total Annual Cost [1] Fuel	Total Annual Cost [1] Energy	Total Annual Energy [1] Electric (kWh)	Total Annual Energy [1] Fuel (MJ)	Carbon Emissions (Mg)	Compare	Potential Energy Savings
Project Default Utility Rates												Weather Data: GBS_06M12_12_335005		
Project Default Utility Rates	--	--	--	--	$0.09	$0.007	--	--	--	--	--	--		
Base Run														
Shangri-La Green Model	6/30/2022 3:43 AM	izzahaida5KEK9	7,579	1,372.5	$0.09	$0.007	$168,092	$29,396	$197,488	1,790,113	3,957,506	--		
Alternate Run(s) of Shangri-La Green Model														
Alt.1	6/30/2022 8:19 AM	izzahaida5KEK9	7,579	1,361.0	$0.09	$0.007	$165,810	$29,396	$195,206	1,765,814	3,957,506	--		
Alt.2	6/30/2022 8:22 AM	izzahaida5KEK9	7,579	1,429.7	$0.09	$0.007	$179,320	$29,419	$208,739	1,909,694	3,960,544	--		
Alt. 3	6/30/2022 8:23 AM	izzahaida5KEK9	7,579	1,362.8	$0.09	$0.007	$166,160	$29,399	$195,559	1,769,541	3,957,932	--		

Fig. 15. General Result before comparison

Name	Date	User Name	Floor Area (m²)	Energy Use Intensity (MJ/m²/year)	Electric Cost (/kWh)	Fuel Cost (/MJ)	Total Annual Cost [1] Electric	Total Annual Cost [1] Fuel	Total Annual Cost [1] Energy	Total Annual Energy [1] Electric (kWh)	Total Annual Energy [1] Fuel (MJ)	Carbon Emissions (Mg)	Compare	Potential Energy Savings
Project Default Utility Rates												Weather Data: GBS_06M12_12_335005		
Project Default Utility Rates	--	--	--	--	$0.00	$0.00	--	--	--	--	--	--		
Base Run														
Shangri-La Green Model	6/30/2022 3:43 AM	izzahaida5KEK9	7,579	0.0	$0.00	$0.00	$0	$0	$0	0	0	--		
Alternate Run(s) of Shangri-La Green Model														
Alt.1	6/30/2022 8:19 AM	izzahaida5KEK9	7,579	-11.5	$0.00	$0.00	-$2,282	$0	-$2,282	-24,299	0	--		
Alt.2	6/30/2022 8:22 AM	izzahaida5KEK9	7,579	57.2	$0.00	$0.00	$11,229	$23	$11,251	119,581	3,038	--		
Alt. 3	6/30/2022 8:23 AM	izzahaida5KEK9	7,579	-9.7	$0.00	$0.00	-$1,932	$3	-$1,929	-20,572	426	--		

Fig. 16. Design Alternatives comparison

Table 3
Total Annual Cost Comparison

Alt.	Energy Use Intensity (EUI) (MJ/m²/year)	Total Annual Cost		
		Electric	Fuel	Energy
1	-11.5	-$2,283	$0	-$2,282
2	57.2	$11,229	$23	$119,581
3	-0.7	-$1,932	$3	-$1,929

From the result comparison, we can see that Alternative 1 and 3 showed a reduction in the energy use intensity which in turn results in the reduction of total annual electricity and energy cost for the building. Alternative 2 on the other hand showed a noteworthy upsurge in total energy use intensity and we can see clearly that the annual cost for the energies has become higher as well as the total energy consumed annually. Based on the variables as stated in Table 2, although the Clear Low-E insulated glass has been used, it does not give good results to overall building performance compared to making the opening size for the East-West side smaller for Alternative 1 or introducing 1/3 shading height for the windows for Alternative 3. In addition, the difference between Alternative 1 and Alternative 3 might be caused by the size of the opening. The east-west side was on the hotter side, especially in the morning and the evening. With smaller openings, less heat will be able to enter the building, making it cooler and using less energy as shown by Alternative 1.

Based on the result analysis, we can deduce that Alternative 1 is the best alternative for design optimization considering the final cost value. However, there are still many factors that need to be taken into consideration by the green resort management to fully optimized their energy usage and annual cost.

5. Conclusion

It can be concluded that a significant amount of savings regarding energy costs and water usage can be achieved through the application of green approaches and consideration in building design. This study also proved that even the slightest change can result in a better energy cost analysis. During the research phases, there are some limitations that need to be addressed. In terms of software usage, the workflow structure for Building Performance analysis often requires the BIM model to be exported externally into various formats such as ifc or gbXML. Data loss and errors due to multiple data entries might happen which can cause unreliable building performance analysis results. Thus, careful consideration of choosing the software to be used must be done beforehand by comparing the existing BIM software.

Next, in terms of data collection on-site, there are limitations from the building management as they need to protect the confidentiality of their building system for safety purposes as there is certain information needed for building performance analysis that cannot be disclosed even for the academic purpose which results in assumption and general data entered. The reliability and relevance of the simulation results will increase tremendously if the previous statistical data in form of annual energy usage or monthly energy usage of the chosen case study is managed to be obtained from the authority as it contains real-time numerical values.

The analysis part is also technically challenging because it involves a lot of data entry and steps that need to be heeded. Therefore, the person who handled the analysis also must also be skilled enough and have a considerable understanding of the functional aspect of sustainability assessment. All in all, it is evidently clear that it is always beneficial in terms of cost to construct a green building, especially in the long run and BIM can be an important tool to help generate the numbers and design alternatives needed for a better future.

Acknowledgment
The author would like to acknowledge research funding from Short Term Research Grant, Universiti Sains Malaysia (304/PPBGN/6315299).

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