Analyzing the Energy Usage and Carbon Emission in Office Administrative Block: A Case Study of KTG Linton University Administrative Block, Malaysia

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Abstract

It is now recognized that this world of mankind has a serious danger to the global climate, and therefore urgent action is needed to address it. One of the key steps is to reduce the amount of energy and carbon dioxide emissions. The objective of this study is to make an experiment on factors contributing the energy usage of the Administrative block including carbon emission in KTG Education Group University Malaysia, and evaluating the case study using Revit Energy Analysis. While many countries have recognized the importance of the role of Revit energy analysis in energy usage and reduction of carbon emissions, Energy analysis from start to finish. Analyzing a complete or near-final design has little or no effect on a building's operational energy performance. The use of the Administrative Building as case study is to analyze the energy intensity and calculate the carbon emission in the selected room. Two simulations will be performed. The first simulation is based on the existing room and the second is based on improved building design envelope. This paper outlines the result of the two simulations. The Energy Used Intensity (EUI) of the existing room used 284 kWh. In order to fulfill the requirement of Green Building Index NRNC tool, the energy intensity must be below 150 KWh/m^2/year. Therefore, new proposed building envelope has been reduced to ***129kWh*** compared to previous EUI which is 284kWh. Based on Green Building Index NRNC tool, the improved design has achieved the requirement of energy intensity below 150KWh/m^2/year. At the same time carbon emission has been reduce from 148.55kg CO_2 to ***67.5kg CO_2***.

KEYWORDS: Energy intensity; carbon dioxide emission; energy usage; Revit energy Analysis;

1. Introduction

The world faces the challenges of global fever and climate change. Human climate change is the greenhouse gases in nature. Carbon dioxide (CO2) is the most important greenhouse gas, and the world's population is increasing in the first carbon dioxide (CO2) and soil use (IPCC, 2007).

The most important factor in the use of energy and the erosion of carbon dioxide (CO2) in urban areas, where most people have some element of high standard of living and rich supply (Fong et al., 2007a & 2007b; IGES, 2004). Therefore, addressing energy-related problems with energy and carbon dioxide (CO2) should be focused on office areas, and Energy analysis plays an important role in counteracting the global climate, or smaller, reducing the office temperatures of the building.

One of the most important principles in the meaning of energy is to achieve 'progress'. The legally recognized United Nations Development Program (UN) is' the development of current challenges without challenging future generations' ability to address their needs'. To make progress, there are many things to consider. The United Nations Economic and Social Development Center has set up areas for development, climate change, and "energy" of major policies (UN, 2007). Therefore, climate change and energy issues should be considered as one of the key objectives in the energy analysis system. However, the study shows that population growth and economic growth are the major motor vehicles since increased energy usage and carbon dioxide (CO2) (Fong et al., 2007a, IGES, 2004). Therefore, it would be a great challenge to maintain the quality of life in these cities while maintaining energy usage and carbon dioxide (CO2).

This study examines the current situation of energy usage and reduction of carbon dioxide (CO2) emission from KTG Education Group University Malaysia, a developing country that is experiencing rapid economic transformation, industrialization and population expansion, with particular emphasis on city context energy usage and carbon dioxide (CO2) emissions. The study also investigates the current considerations of energy usage and carbon dioxide (CO2) emissions in the spatial energy process of the administrative building. This paper provides a guide for further consideration in incorporating energy and carbon dioxide (CO2) issues as the core part of Energy analysis process, in achieving sustainable development based on the concept of low carbon emission.

Global warming and climate change are the two greatest issues to mankind currently. The urgency to fight against them has drawn serious attentions for leaders, scientists and individuals all over the world. In fact, the event that for the first time drawing attentions from the world on the global warming and climate change issues can be traced back to the first “World Climate Conference” organized by the World Meteorological Organization (WMO) in 1979. The conference expressed concern that “continued expansion of man’s activities on earth may cause significant extended regional and even global changes of climate”, and it called for “global cooperation to explore the possible future course of global climate and to take this new understanding into account in planning for the future development of human society” (IPCC, 2004). Subsequent to the said conference, various international efforts have been taken to monitor the climate change and to mitigate it. In 1988, the IPCC was set up and followed by the adoption of the United Nations Framework Convention on Climate Change (UNFCCC).

Presently the primary international policy framework against global warming and climate change is the UNFCCC, specifically the Kyoto Protocol, which sets emission limits for many of the world's most economically developed nations. Under the Kyoto Protocol, the participating developed countries are committed to reduce their GHG emissions on an average of about 5% by the target years of 2008 to 2012 (UN, 1998). For post-Kyoto Protocol, during the United Nations Climate Change Conference 2007 held in Bali, Indonesia, it was decided to adopt the Bali Roadmap, which charts the course for a new negotiating process to be concluded by 2009 that will ultimately lead to a post-2012 international agreement on climate change (UNFCCC, 2007). Also, during the G8 Summit 2007 held in Heiligendamm on 6-8 June 2007, the participating countries have agreed to consider seriously the target of halving of GHG emissions by 2050 (G8, 2007). Presently, the common global target is to cut the GHG emissions, particularly CO2 emissions, by 50% of the present level by year 2050. In this respect, Japan has launched the national campaign of 'Cool Earth 50', which targeting to cut the CO2 emissions up to half of the present level, by the year 2050. Also, the State of California of the United States is aiming to cut the emission to 80% below 1990 level, while London has set the target of 60% carbon emission reduction from 2000 level, both with the common target year of 2050 (TMG, 2006).

CO2 is the most anthropogenic GHG (human being caused) in the atmosphere. CO2 emissions arise from several sources, particularly fossil fuel combustion in the generation, industry, residential and transport sectors. It is released into the atmosphere primarily by combustion of fossil fuels such as coal, oil or natural gas, and renewable fuels such as biomass (IPCC, 2005).

According to the 2006 International Energy Survey (see Figure 1), the world's CO2 emissions from fossil fuel consumption are expected to grow at an average rate of 2.1% per annum from

2003 to 2030. World CO2 emissions from fossil utilization Fuel is expected to increase from about 25,000 billion metric tons in 2003, to more than 40,000 billion tons by 2030.

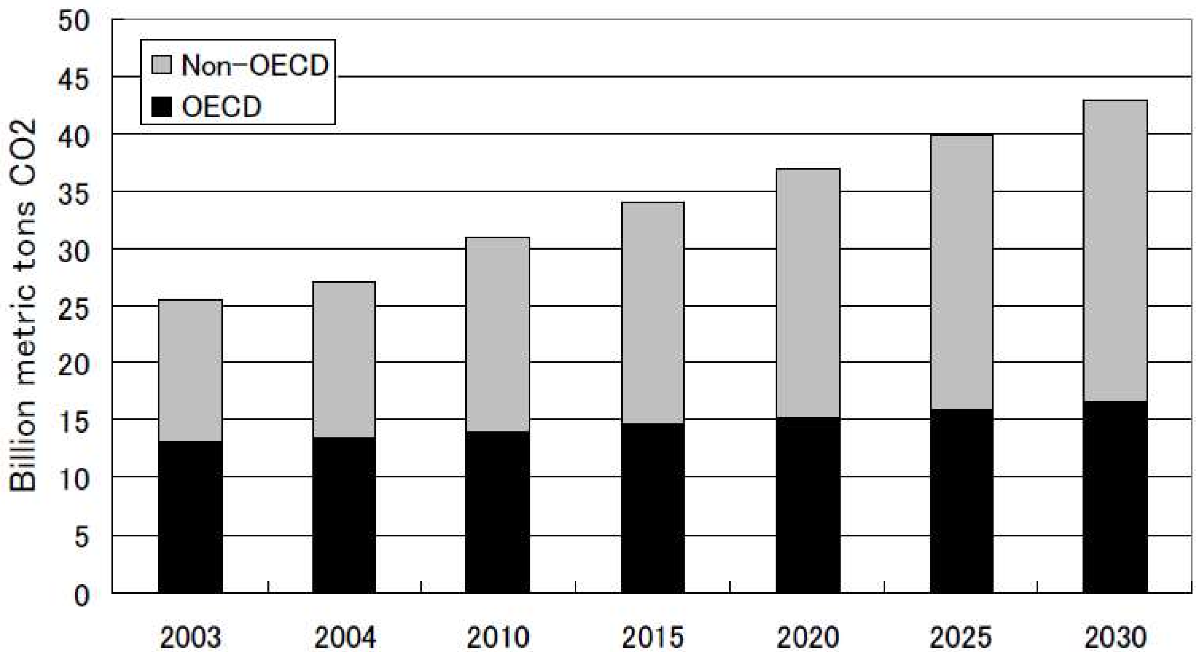

Figure 1: World energy-related CO2 emissions by region, 1990-2030 (EIA, 2007)

The relative contribution of different fossil fuels to the amount of CO2-related emissions associated with emissions has changed over time as shown in Figure 2. Increased trend of CO2 emission trends observed for all types of fuel and they are projected to steadily increase steadily over the projection period up to 2030 However, in the case of emissions from petroleum and other liquids that form the largest share (42%) of the world's total emissions in 1990, have been overcome by coal since 2005. By 2030, it is projected that coal and liquids (petroleum and other liquids) will each contribute 43% and 36% of the total world emissions. The increased coal price reflects an important role in the energy mix of non-OECD countries, especially China and India (EIA, 2007). Also, similar trends are seen in Malaysia. In 1990, China and India combined were 13% of world emissions, but in 2004 the share increased to 22%, largely due to the strong increase in coal consumption in both countries. This trend is expected to continue, and by 2030 the release of CO_2 from China and India combined is expected to account for 31% of the world's total disbursements, with China itself responsible for 26% of the world's total.

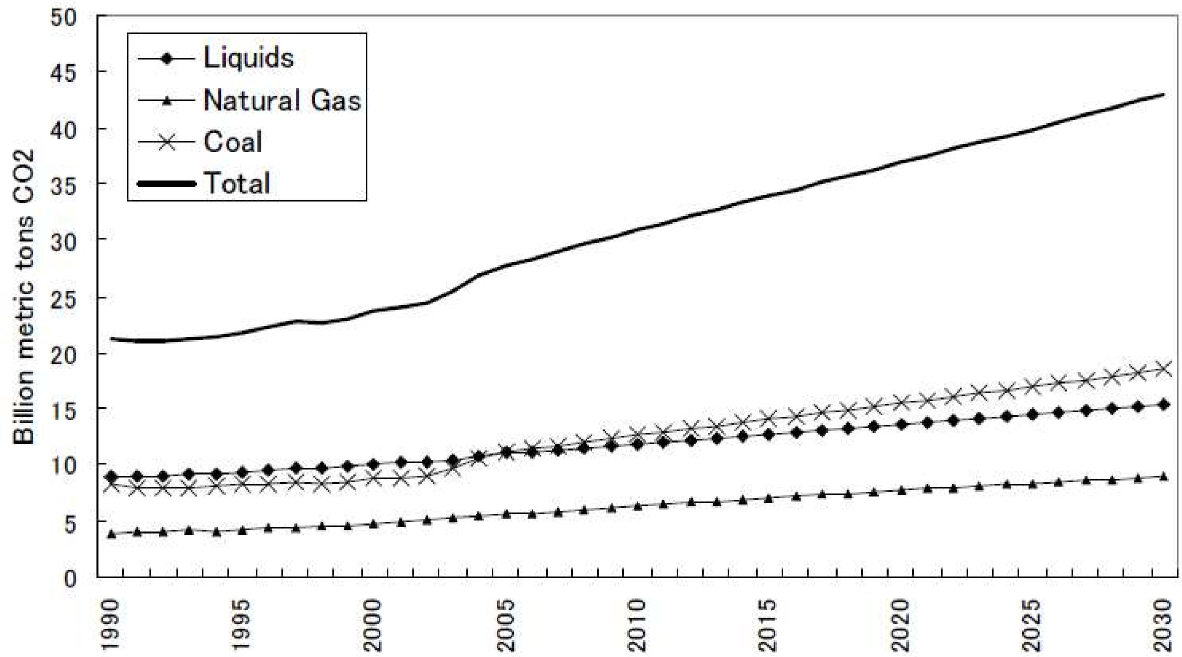

Figure 2: World energy-related CO_2 emissions by fuel type, 1990-2030 (EIA, 2007)

Figure 2 above reveals that world CO_2 emissions are on an upward trend. Each country contributes CO_2 to the atmosphere. From this figure it can be seen that the growth rate of CO_2 emissions from non-OECD countries is higher than OECD countries. 2004 marks the first time in history that CO_2 emissions related to energy from non-OECD countries go beyond OECD countries. Furthermore, since the annual average increase in emissions from 2004 to 2030 in non-OECD countries (2.6%) was more than three times the increase for OECD countries (0.8%), CO_2 emissions from non-OECD countries 2030, at 26.2 billion tons, is expected to exceed 57% of OECD countries.

Building performance improvements are important for reducing emissions of greenhouse gases and reducing energy costs. However, identifying potential possibility for energy efficiency retrofits poses significant challenges. Builders, developers, owners, facility managers, insurers, financiers, and regulators all struggle to get the information they need to support their building decisions.

To evaluate and update the existing portfolio of buildings systematically, the construction industry needs a scalable process to assess building performance quickly, cost-effective, accurate and efficient.

2. Literature Review

According to 2011 Autodesk, Inc. the design and power supply in current buildings represents opportunities to reduce the cost of energy and protection from the risk of energy consumption. According to this, there are several local and regional statistics to improve the project. These documents, such as energy, global climate change, and economic development systems, use energy efficiently for the construction of buildings around the world.

To address these economic and energy issues in terms of funding, contributions, and demand, industry manufacturers must be able to accelerate, plan, and focus on their efforts. However, we are facing the challenge of determining the potential of energy reserves in office existing building information that is crucial to finding outcomes and refining.

Most of the methods used today are expensive and difficult. The most successful experiments are those who rely on energy analysis and follow the steps below:

- Consideration of current data - Architectural (geometry) architecture, user history, hardware and equipment, location information and schedule, etc.

- Provide energy usage - Using the data development information to improve energy efficiency.
- Calibration - Switching awareness systems to energy usage to ensure energy efficiency is compatible with user history in the compliant gate
- Energy levels - Improve energy efficiency to evaluate energy and energy savings for different energy components. Calculate prices to implement the steps and schedule the list of items based on the simplest.

Once the building structure is completed, you are ready to make energy simulation and analysis. Revit Conceptual Energy Analysis features are used for the analysis.

The Revit Conceptual Energy Analysis works with the energy generation system from a review of the revision process and results according to the user designing parameters such as building location and type, with operational times. The search results view the results of the analysis in a separate window via graphs, charts, and tables. (© 2011 Autodesk, Inc. All rights reserved).

Green Building uses the DOE-2 technician to study energy analysis and provide opportunities for review and complete research if available needed. The user has the ability to continue analysis in some software using fay XML files that can be downloaded from the forms of Revit Conceptual Energy Analysis features and Green building index NRNC tool

In order to fulfill the requirement of Green Building Index NRNC tool, the energy intensity must be below 150 KWh/m^2/year. Therefore, the proposed building envelopes is needed to reduce the energy intensity as required and at the same time reduce the carbon emission of the building by the used of Revit Energy Analysis.

The objectives of the analysis is to improve the Energy Intensity and lower the carbon emission of our building, some design improvement has to be done on the analysis.

3. Building Energy Simulation And Carbon Emission

3.1 Findings and Discussion

The experiment target will be on one of the office in the Administrative Building. Produce an Energy Analysis through Revit Software and also calculate the carbon Emission of the particular room.

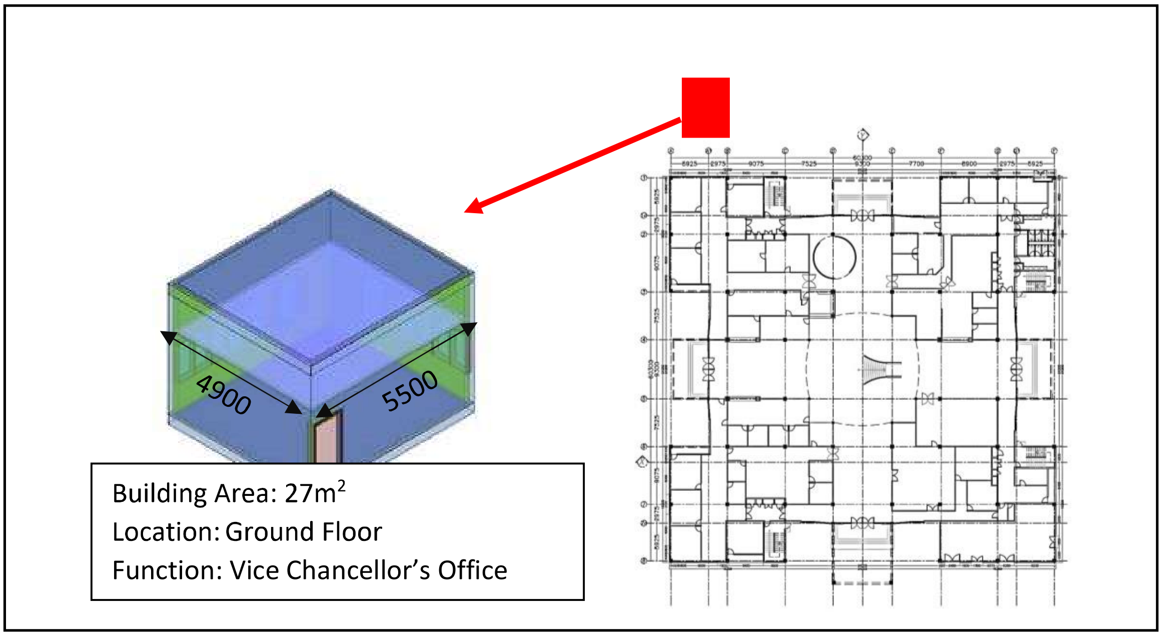

Figure 3: Brief Introduction of Vice Chancellor's Office (KTG University)

3.1.1 The first simulation of the existing room Energy intensity analysis result from Revit software is as followed

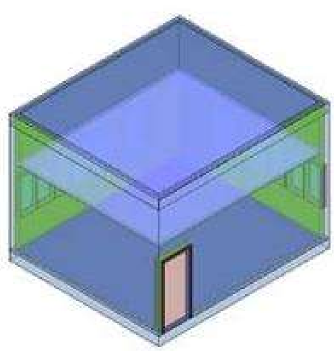

Figure 4: Energy analysis result image (existing room)

Building performance factors

Table 1: Building performance factors Table (existing room)

Location	Mantin Malaysia
Weather Station	7833990
Outdoor Temperature	Max33^{0}c/min:26^0 c
Floor Area	27m^2
Exterior Wall Area	74m^2
Average Lighting Power	12.92W/m^2
People	6 people
Exterior Window Ratio	0.11
Electrical Cost	$0.09/Kwh
Fuel Cost	$0.78/Therm

Energy Use Intensity

Table 2: Energy Use Intensity Table (existing room)

Electricity EUI	284 kwh/sm/year
Fuel EUI	193MJ /sm/year
Total	1.217 MJ/sm/year

Life Cycle Energy Use/Cost

Table 3: Life Cycle Energy Use/Cost Table (existing room)

Life Cycle Electricity Use	233.642 kwh
Life Cycle Fuel Use	158.373MJ
Life Cycle Energy Use	$10.494

*30year life and 6.1% discount rate for costs

Renewable Energy potential

Table 4: Renewable Energy Potential Table (existing room)

Roof Mounted PV System (Low efficiency)	2.063kwh/year
Roof Mounted PV System (Medium efficiency)	4.125Kwh/year
Roof Mounted PV System (High efficiency)	6.188Kwh/year
Single 15^0 Wind Turbine Potential	355 Kwh/year

*PV efficiencies are assumed to be 5%, 10% and 15% for low, medium and high efficiency systems

Annual Carbon Emissions and Annual Energy Use/Cost

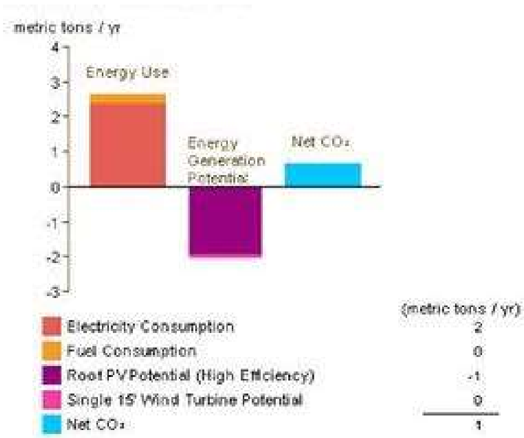

Figure 5: Annual Carbon Emissions chat (Existing room)

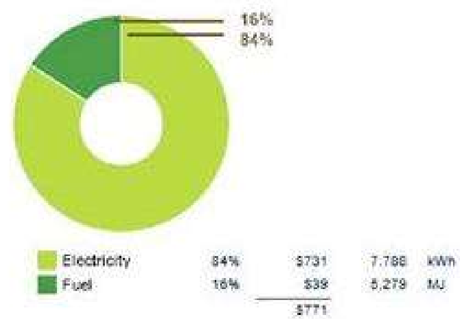

Figure 6: Annual Energy Use/Cost chat (Existing room)

The Annual carbon emission in the chat has an energy use of electricity consumption of 2 metric tons / year with fuel consumption of 0 metric tons / year. The energy generation potential use -1 metric tons / year of roof PV potential (high efficiency) with single 15^0 wind turbine potential. In all the net carbon emissions is 1 metric tons / year.

The annual energy use/cost chat show the electrical consumption of 84% of electricity and 16% of fuel because of the metric tons / year used in the annual carbon emissions.

Energy Use: Fuel and Energy Use: Electricity

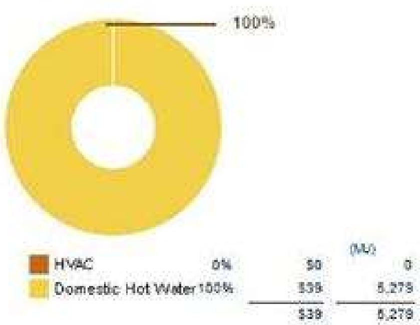

Figure 7: Energy Use: Fuel chat chats (Existing room)

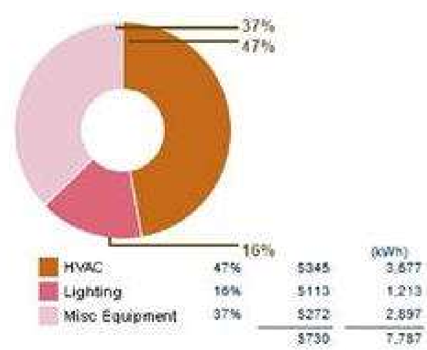

Figure 8: Energy Use: Electricity (Existing room)

The energy use: fuel chat show the HVAC at 0% usage and 100% of Domestic hot water used in metric tons / year used energy.

The energy use: electricity chats shows the HVAC at 47%, lighting at 16% and misc equipment at 37% in kwh/year in energy use.

Monthly Heating Load

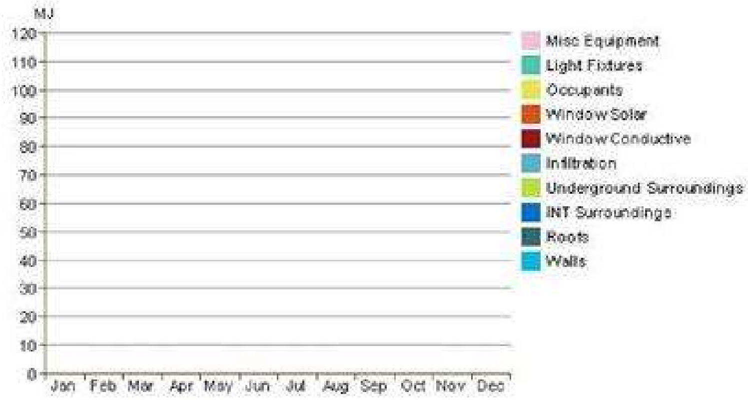

Figure 9: Monthly Heating Load chat (existing room)

Monthly Cooling Load

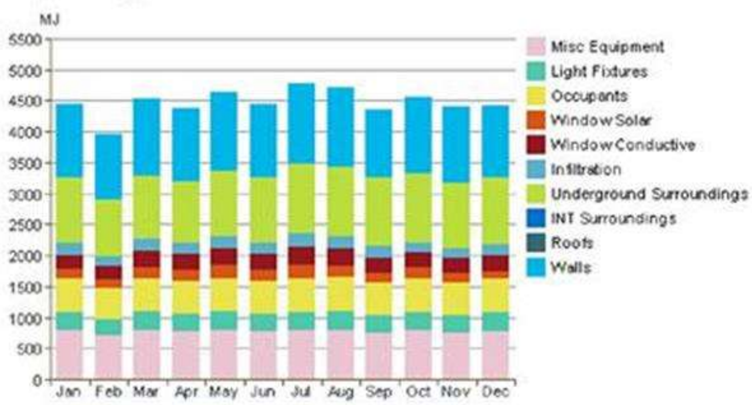

Figure 10: Monthly Cooling Load chat (existing room)

Heating and cooling energy consumption data are combined in Figure 9 & 10. Here, the overall effect of the monthly cooling load features is realized. The figure shows that there is no much difference between the best case (lowest energy use) and worst case (highest energy use) design scenarios monthly.

3.1.2 The carbon emission calculation of the existing room from the simulation result will be calculated in CARBON EMISSION UNIT

Convert kWh electricity to kg CO2

In order to convert electricity consumed in kWh to kg of carbon dioxide, the energy use should be multiplied by a conversion factor. This is show in the table below.

The conversion factors for energy sources are:

Table 5: Calculation Formulas for Carbon Emission

Energy source (kWh)	Conversion factor (kg CO2 / kwh)
Electricity	0.523
Natural gas	0.185
Burning oil (for heating)	0.245

CARBON EMISSION CALCULATION FOR EXISTING ROOM

Energy use = 284 kWh

Conversion factor = 0.523

Carbon Emission: 284 kWh x 0.523 = 148.5 kg CO2

If 284 kWh units of electricity were consumed, then 148.5 kg CO_2 was produced.

The Energy Used Intensity (EUI) of the existing room used 284 kWh. In order to fulfill the requirement of Green Building Index NRNC tool, the energy intensity must be below 150 KWh/m^2/year. Therefore, new proposed building envelope is needed to reduce the energy intensity as required and at the same time reduce the carbon emission of the building. New.greenbuildingindex.org. (2017).

Table 6: GBI NRNC tool EE 5

EE5	ADVANCED EE PERFORMANCE			
	Exceed Energy Efficiency (EE) performance better than the baseline minimum to reduce energy consumption in the building. Achieve Building Energy Intensity (BEI) ≤ 150 kWh/m²yr as defined under GBI reference (using BEIT Software or other GBI approved software(s)), ***OR***	2	15	
	BEI ≤ 140, ***OR***	3		
	BEI ≤ 130, ***OR***	5		
	BEI ≤ 120, ***OR***	8		
	BEI ≤ 110, ***OR***	10		
	BEI ≤ 100, ***OR***	12		
	BEI ≤ 90	15		

From the existing building result to improve the Energy Intensity and lower the carbon emission of our building, we had done some design improvement. Proposed designs include:

- Wall insulation is installed to achieve a lower U-value
- Single glaze window is replaced with triple glazed window with a lower U-Value and Solar Heat Gain Coefficient (SHGC)
- 1m horizontal shading device is added to each set of windows.

3.1.3 The second simulation of the improved design room Energy intensity analysis result from Revit software using the proposed designs above is as followed

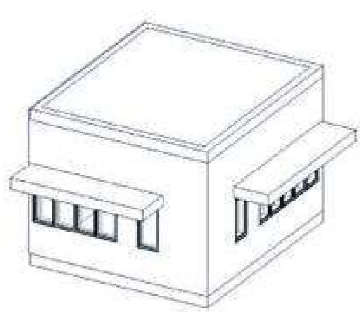

Figure 11: Energy analysis result image (improved design)

Building performance factors

Table 7: Building performance factors Table (improved design)

Location	Mantin Malaysia
Weather Station	1447060
Outdoor Temperature	Max35^0c/min:20^0 c
Floor Area	$27m^2$
Exterior Wall Area	$68m^2$
Average Lighting Power	$12.92W/m^2$
People	6 people
Exterior Window Ratio	0.10
Electrical Cost	$0.09/Kwh
Fuel Cost	$0.78/Therm

Energy Use Intensity

Table 8: Energy Use Intensity Table (improved design)

Electricity EUI	129 kwh/sm/year
Fuel EUI	179MJ /sm/year
Total	752MJ/sm/year

Life Cycle Energy Use/Cost

Table 9: Life Cycle Energy Use/Cost Table (improved design)

Life Cycle Electricity Use	130.669kwh
Life Cycle Fuel Use	147.061MJ
Life Cycle Energy Use	$6.066

*30year life and 6.1% discount rate for costs

Renewable Energy potential

Figure 10: Renewable Energy Potential Table (improved design)

Roof Mounted PV System (Low efficiency)	2.385kwh/year
Roof Mounted PV System (Medium efficiency)	4.771Kwh/year
Roof Mounted PV System (High efficiency)	7.156Kwh/year
Single 15^0 Wind Turbine Potential	106Kwh/year

*PV efficiencies are assumed to be 5%, 10% and 15% for low, medium and high efficiency systems

Annual Carbon Emissions and Annual Energy Use/Cost

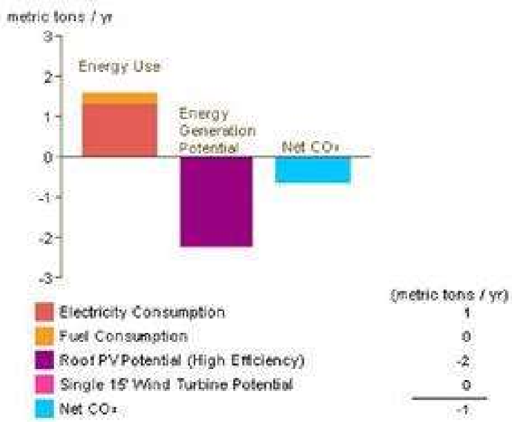

Figure 12: Annual Carbon Emissions chat (improved design)

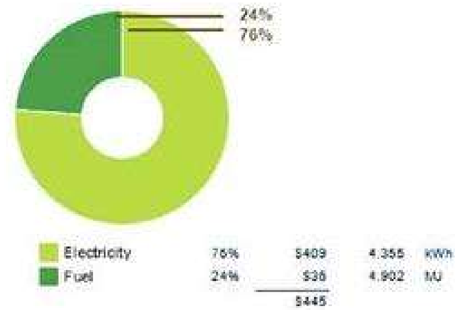

Figure 13: Annual Energy Use/Cost chat (improved design)

The Annual carbon emission in the chat has an energy use of electricity consumption of 1 metric tons / year with fuel consumption of 0 metric tons / year. The energy generation potential use -2 metric tons / year of roof PV potential (high efficiency) with single 15^0 wind turbine potential. In all the net carbon emissions is -1 metric tons / year.

The annual energy use/cost chat show the electrical consumption of 76% of electricity and 24% of fuel because of the metric tons / year used in the annual carbon emissions.

Energy Use: Fuel and Energy Use: Electricity

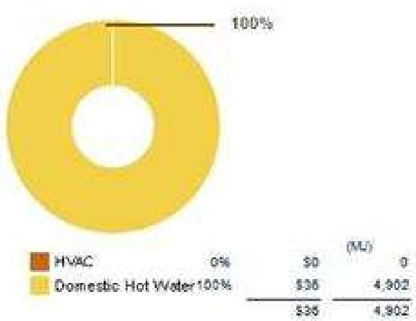

Figure 14: Energy Use: Fuel chat (Improved design)

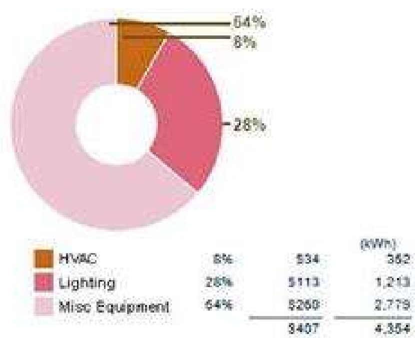

Figure 15: Energy Use: Electricity chats (Improved design)

The energy use: fuel chat show the HVAC at 0% usage and 100% of Domestic hot water used in metric tons / year used energy in the annual carbon emissions.

The energy use: electricity chat show the HVAC at 0% usage and 100% of Domestic hot water used in metric tons / year used energy in the annual carbon emissions.

Monthly Heating Load

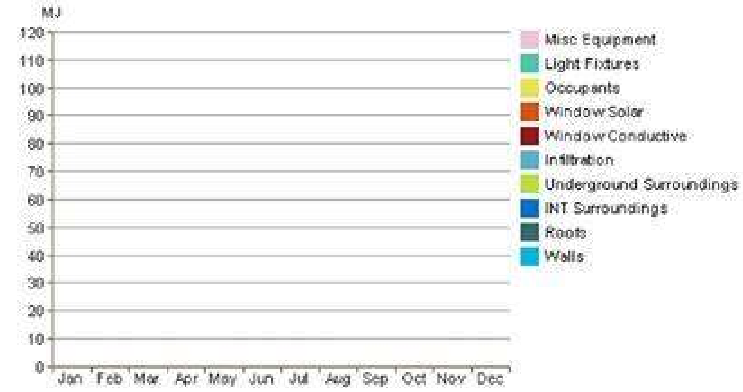

Figure 16: Monthly Heating Load chat (improved design)

Monthly Cooling Load

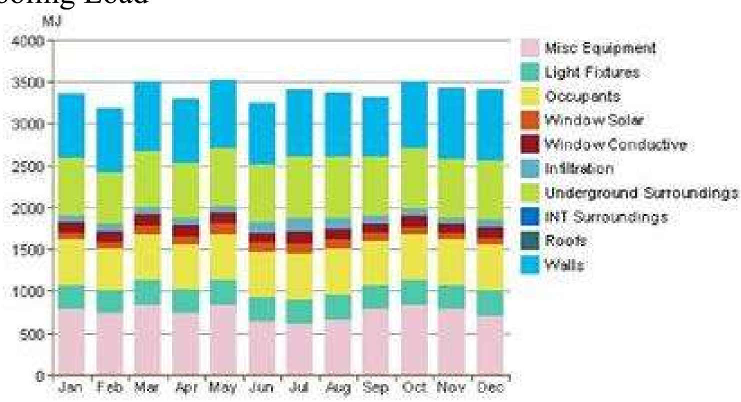

Figure 17: Monthly Cooling Load chat (improved design)

Heating and cooling energy consumption data are combined in Figure 16 & 17. Here, the overall effect of the monthly cooling load features is realized. The figure shows that there is no much difference between the best case (lowest energy use) and worst case (highest energy use) design scenarios.

Annual cooling energy consumption for the all scenarios is given. Figure 17 illustrates the trade-off associated with building overhangs used. The overhang use less cooling energy than the scenarios without. The figure shows that the overhang design element creates a greater separation of the data than the thermal mass. Moreover, the separation between the overhang/no-overhang scenarios increases as the building's glazed areas are oriented toward the sun (in the range of 120 to 210 degrees). The mass's influence is less significant due to the sun's position in the sky during the cooling months of the year. This dampens the heating effect of the mass. The mass's influence could become more significant if natural ventilation or night cooling strategies were employed, creating a mass cooling effect. However, these methods are not explored at this time.

3.1.4 The carbon emission calculation of the improved design room from the simulation result will be calculated also using table 5 convert formula

Energy use = 129 kWh

Conversion factor = 0.523

Carbon Emission:

129 kWh x 0.523 = 67.5 kg CO2

If 129kWh units of electricity were consumed, then 67.5kg CO_2 was produced.

The Energy Used Intensity has been reducing to ***129kWh*** compared to previous EUI which is 284kWh. Based on Green Building Index NRNC tool, the improved design has achieved the requirement of energy intensity below 150KWh/m^2/year. At the same time carbon emission has been reduce from 148.55kg CO_2 to ***67.5kg CO_2***.

4. CONCLUSION:

There are many ways, in fact, that can protect energy usage and reduce carbon dioxide (CO2) emissions through Architectural software. As the case of Malaysia, being among the developing countries, it is important to find out the best practices with minimum energy consumption and carbon dioxide (CO2) emission, in achieving the goal of improving the Energy Intensity and lower the carbon emission.

Overall, although it is widely recognized that in achieving low energy consumption and low carbon dioxide (CO2) emissions building, it is important to conduct continuous research on energy-saving technologies and measures in various energy sectors used such as transport, industry, commercial and residential, and More importantly, it requires a holistic analysis and a clear understanding of the nature of the highest energy use and CO2 emissions.

Analysis of Revit energy can reduce the cost of variables associated with energy assessments. This allows massive assessment in a short time disabling traditional methods of energy analysis and building audit techniques, thereby assisting the building construction industry to create a low carbon-built environment.

Analyzing the complete or near-end design has little or no effect on the performance of building operations. But leveraging energy analysis as a decision maker throughout the design life cycle- from conceptual forming, through complex BIM modeling-can have tremendous effects. This approach helps architects capture performance improvement opportunities throughout the design development process, which potentially saves building owners with wealth in operational cost of energy and significantly reduces the emission of operating carbon. Revit empowers architects to do just by using Insight, cloud-based energy analysis software that is a service available to Revit and Autodesk AEC Collection customers. Revit Official Blog. (2017).

The main contributor to the global warming phenomenon is energy use and land use change. In this regard, urbanization is one of the most important aspects that cannot be ignored in addressing the problem of global warming, as a major part of energy consumption and emission of CO2 in the cities. Therefore, space planning that deals with planning for land use and urban structures plays a very important role in controlling energy consumption and CO2 emissions in urban systems.

While many countries have recognized the importance of space planning in energy conservation and the reduction of CO2 emissions, in Malaysia, there is still no specific spatial planning policy that is directly related to energy and CO2 issues. On the other hand, in the process of urban planning, efforts have been made primarily to meet high energy demand (which gives more focus on electricity supply) to support the desired high economic growth. Therefore, this paper aims to emphasize the importance of energy conservation and reduction of CO2 as a core consideration in Malaysia, from national to local level.

The main contributors to the global warming phenomenon are energy use and land use change. In this respect, urbanization is one of the essential aspects that must not be neglected in handling global warming issues, as the main portion of energy consumption and CO2 emission is occurring in the cities. Hence, spatial planning that dealing with planning for land use and urban structure is playing a very important role in controlling energy consumption and CO2 emissions in the urban systems.

While many countries have recognized the importance of the role of spatial planning in energy conservation and reduction of CO2 emissions, in Malaysia, to date there is still no specific spatial planning policy that directly deals with the energy and CO2 issues. Instead, in the urban planning process, efforts have been put mainly on fulfilling the high energy demand (which focusing more on electricity supply) so as to support the desired high economic growth. Hence, this paper aims to emphasize the importance of energy conservation and CO2 reduction as the core considerations in the spatial planning process in Malaysia, from national till local levels. (NIES, 2006)

In the preparation of the Structure Plan, for example, rather than trying to meet high energy demand, measures need to be taken to reduce energy consumption and CO2 emissions, to achieve a balance between economic development and environmental conservation. Every proposal in the Structure Plan, to some extent, will affect the energy consumption and emissions of CO2 in the overall planning area. For example, proposals to convert forest areas into commercial development will not only increase CO2 emissions and emissions in the area, but will also reduce carbon sink capacity due to loss of green areas. Therefore, proper consideration should be taken on the impact of each proposal on energy consumption and CO2 emissions. In this case, it is necessary to develop and incorporate decision-making tools to assess the overall impact of the development plan (or reserve options) on urban and regional energy use and CO2 emissions as a whole. This research can help decision makers in environmental conservation. Ho and Fong (2007).

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