Energy Conservation in Buildings

By

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CERTIFICATION OF APPROVAL

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in partial fulfillment of the requirement for the

BACHELOR OF ENGINEERING (Hons)

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Approved by,

____

(Dr. Morteza Khalaji Assadi)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

September 2013

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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Lau Yau Kin

ACKNOWLEDGEMENT

My completion of Final Year Project will not be a reality without the help of many people around me. Hereby, I would like to acknowledge my heartfelt gratitude to those I honour and thank them from the deepest part of my heart.

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ABSTRACT

When the term conservation of energy is used in engineering of energy, it usually means to optimize the usage of energy. The aim of this procedure is to identify the energy reduction demand and alternative energy to improve the conservation of energy in building. Energy consumption in buildings is a major share of the world's total end use of energy. The rapidly growing world energy use has already raised concerns over supply difficulties and heavy environmental impacts such as ozone layer depletion, global warming and climate change. Due to the environment impact, this paper will also discuss the alternative energy can be implemented in order to conserve energy in buildings. There are two ways to reduce energy demand which are by wall insulation and location of the building. Besides that, the author is also introducing solar active and passive system as alternative energy to conserve more energy. This paper presents a detailed research to investigate on energy reduction demand and presents solar active and passive system as alternative energy. In addition, introduction of high efficiency instruments such as air conditioning system and lighting system shall enhance the performance of energy conservation of energy. An integrate tool kit called TRNSYS software to perform the analysis on simulation of energy conservation in building. By using TRNSYS software, we are able to summarize the ideal configuration of data needed for conservation of energy in building. Graph of heat distribution will be the main key component to indicate the energy conservation in building. Any data or researched been done will be incorporated into the software to simulate necessary results.

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CHAPTER 1

INTRODUCTION

1.1 Background Study

Modern use of energy is largely cannot be seen, energy systems are complex and daily practices are significant. With global growing of economics, there have been marked increases in building development projects, and there is a growing concern about energy consumption in buildings. High consummation of energy in buildings not only affects building system and also increases the potential global warming. In this paper, the author identifies two ways of reducing energy demand which are wall insulation and location of the building particularly residential houses in Malaysia. The reason residential houses needed to be studied because mostly of the residential development. The author will extend his research by promoting alternative energy and high efficiency system to optimize the energy conservation among the citizen of the country.

An important component of the building envelope is the wall insulation which able to prevent unnecessary heat transfers into the building. A proper insulation shall cover every part of the building in order to conserve and preserve energy. By having detailed research and calculation, we can optimize the insulation performance of the building and this can result in more efficient energy conservation. The effectiveness of insulation of structure can be measured by its R-value. The R-value designates its resistance for the heat to flow. The higher the R-value, the insulation will be better. With proper research of the wall insulation, the owner of the house is capable identifying suitable type of insulation needed in order to have proper energy conservation in home.

Another element which can reduce the energy demand of the building is the location and orientation of the building itself. In order to conserve energy, the location and orientation has its pros and cons. The advantage of locating in a direct sunlight exposure is it can have the capability to receive maximum amount of solar energy though solar active and passive system. On the other hand, if solar system is not implemented, it causes the building to receive great amount of heat energy and affecting the thermal comfort of the occupant. Therefore, the building requires extra energy usage for the air conditioning system to overcome the excessive heat.

Solar energy is the energy converted from the sun through the form of solar radiation. The heat generated from the sun is stored and distributed to power residential and industrial heating and cooling systems through the use of photovoltaic, or PV, panels. There are two types of solar system to be discussed. Active solar system is the uses of photovoltaic panels and solar thermal collectors to harness the energy. Solar water heaters represent a good and popular use of solar energy in a mechanical system. In Malaysia where water heating requirements are modest because of the temperate climate, many residential houses have solar water heaters fitted to their roofs. However, because of lack of awareness and knowledge regarding solar water system, optimum energy usage cannot be fulfilled. Passive solar system includes orienting a building to the Sun and designing spaces that naturally lighting and ventilation to reduce usage to electricity consumption.

By implying high efficiency instrument such as air conditioning system and lighting system, it can reduce energy wastage. For air conditioning system, air conditioning unit need to be selected according to the engineering factors. Oversize air conditioning unit will cause more energy to be use. For the lighting system, we can include lux meter, spectrometer and light dependent resistor to improve the system. For example, when the natural lighting is not enough to light the room, the spectrometer will detect the low lux and call for artificial lighting to be on.

The software TRNSYS will be used to simulate designs using multi-zone buildings and their components for the residential housing in Malaysia. In this paper, the author required to design a multi-zone building which is residential house with the correct parameters and configuration used in Malaysia. The house system needs to be defined first followed by all possible components used in the system. All input, output and parameter of each component will be defined in the software. Result and analysis are based on the data obtained which the author is required to discuss the amount of sensible and latent heat for the sample. TRNSYS also provide tool named weather data reader and processing to read weather data from external source or to generate weather data from weather data generator provided by TRNSYS. In general, there are two kind of simulation. They are steady state simulation (under steady state condition) and transient simulation (under transient condition).

1.2 Problem Statement

Energy consumption in buildings is an important part of total energy consummation in each country. However, overly high consummation of energy in buildings not only affect economically wise and also increases the potential global warming. Therefore, in order to conserve energy particularly buildings in Malaysia, several methods can be used to reduce energy consumption and save electricity.

1.3 Objectives

The author decided to propose the most suitable data configuration for energy conservation of a residential house (Semi-D) located in Ipoh, Perak. The author decided to use wall insulation of the building and location and orientation of building as the parameters to be used in TRNSYS software. In addition, the author also will implement alternative energy which is suitable to be used in Malaysia which is solar active and passive system. The author added two elements of high efficiency system which is air conditioning system and lighting system to improve energy conservation. At the end of the research, the author hopes that implying the good conservation of energy, the selected residential house can be fully functional with minimum usage of electricity.

1.4 Scope of Study

In this project, the main subjects under analysis are:

1. Wall insulation of the building
2. Location and orientation of the building
3. Solar active system of the building
4. Solar passive system of the building
5. Air conditioning system
6. Lighting system

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CHAPTER 2

LITERATURE REVIEW

Energy is one of the most basic requirements in life and a fundamental element for all economic systems. The increase in energy prices due to the global shortage in low cost energy resources has initiated energy conservation studies. Thus, in this paper, the author briefing discussed the parameters needed for energy conservation.

2.1 Methods reducing energy demand

2.1.1 Wall Insulation

The external walls of a structure are the interface between its interior and the outdoor environment. [1] It should be insulated according to the outside environmental condition and indoor thermal comfort condition. [1] Heat gain through wall surfaces is derived from solar radiation. In this paper, the wall insulation properties will be introduced into TRNSYS in order to produce energy conservation results. [3] Autoclaved aerated concrete wall is a new form of wall insulation where introducing air into prepared slurry. Then, the air is entrapped in a closed cell bricks. According to Scientific Research by Kuwait, the thermal conductivity (k) is average 0.15 W m- 1 C -1. With this, it is the advantage of the autoclaved aerated bricks compare to normal bricks. [1] Optimum insulation was calculated by considering heat losses from external walls with the general formula $q= U (T_b - T_o)$ where U is the overall heat transfer coefficient, T_b is base temperature and T_o is mean daily temperature. [4] Another research has been carried out by Rosemary Bom to investigate the findings of thermal performance of wall using structural brickwork with expanded polystyrene. [4] The expanded polystyrene consists of 98% air and 2% of solid matter. Due to its good thermal resistant, Rosemary Bom proved that the difference between temperature of block with expanded polystyrene and block without it clearly shows efficiency of disparity amid them.

2.1.2 Location and Orientation of the Building

The location and orientation of the building is crucial in order to conserve energy. [2] Malaysia (located between 1°N to 7°N and 100°E to 120°E) is in the tropical region. Precisely understanding the location, the structure needed to be orientated at the correct position. [1] Engineer needs to pay attention on position of the building facing the direct sunlight as the solar intensity is the greatest. This is to filter excessive solar radiation from entering the building which is the most major contributor to heat gain if it faces on the highest solar radiation. [6] Weather data analyses should be the primary step and the backbone for continuing energy conservation research. The analyses can provide important guides for building energy systems design and select the ideal renewable energy system. [6] On the other hand, in order to use less electricity for artificial, natural lighting can be utilized by orientate the structure to medium concentrated solar radiation. With this, buildings with good natural light penetration will save considerable energy costs during the daytime.

2.2 Alternative Energy

2.2.1 Solar Active System

The solar active system is one of the reliable alternative energy been introduced in order to optimize the solar radiation. [8]Solar active system requires electrical or mechanical equipment in order to perform the conversion of energy in order to be used by other system. Active solar heating relies strongly on three components, a solar collector to absorb the solar energy, a solar storage system, and a heat transfer system to disperse the heat to the appropriate places in your equipment. [6]Active solar collectors contain either air or a liquid as a conductor. Energy generated from solar is used to heat up water system for residential buildings. By having this water heater system, electricity consumption can be minimized and more energy is conserved.

[6] In TRNSYS, element needed to take into account is the angle of the solar collect, solar insolation and cell operating temperature. The size of the solar collectors is needed to be considered in order to have maximum solar absorption. Determining the configuration is crucial in order to find the ideal solution to maximize solar absorption.

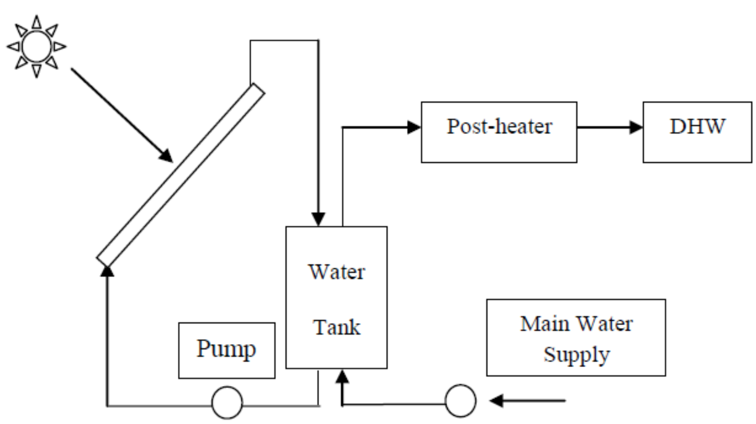


FIGURE 1: Illustration of solar active system

2.2.2 Solar Passive System

[8]The passive solar system does not involve mechanical devices or the use of conventional energy sources beyond that needed to regulate dampers and other controls. As the sun's rays pass through the glass windows or structure, the interior absorbs and retains the heat. According to Crosbie (1998), the dwelling should have large area of south facing glazing to maximize solar gain. Large window can provide a good amount of natural lighting. [9] Since permitting natural light into the structure, they present a significant potential energy saving. By implying this concept, TRNSYS is able to calculate the electricity saving with minimum usage of artificial lighting. [8] Besides that, thermal heat inside the structure can be regulated and good natural ventilation when having a good passive solar system. Features such as curtain shall be introduced to prevent the building from overheating. Modelling this concept in buildings can be beneficial and cost saving. In terms of design, success of the passive solar system depends on orientation and the thermal mass of the structure's exterior walls, which means their ability to store and redistribute heat.

2.3 High Efficiency Instrument

2.3.1 Air Conditioning System

[11] It is estimated that approximately 10% of all electricity energy consumed in the world is expended by building HVAC system. [10] Due to its overwhelming energy usage, a simplified engineering formula can be used in order to select a proper air conditioning unit. The amount of heat generated is known as the heat gain or heat load. Heat is measured in either British Thermal Units (BTU) or Kilowatts (KW). 1KW is equivalent to 3412 BTUs. The heat load depends on a number of factors, by taking into account those that apply in your circumstances and adding them together a reasonably accurate measure of the total heat can be calculated.

Factors include:

- The floor area of the room
- The size and position of windows, and whether they have blinds or shades
- The number of room occupants (if any)
- The heat generated by equipment
- The heat generated by lighting

2.3.2 Lighting System

[13] Lighting system is a major energy consumer. Energy can be saved by using energy efficient equipment, effective controls and careful design. [12] The present lighting system consists of tungsten filament bulbs which consume more power, fluorescent lamps, are not so good in energy conservation. A method introduced is adding lighting control. [13] Photo sensors control monitor daylight conditions and allow fixture to operate only when necessary. The photo sensors detect the quantity of light or lux of the light intensity, then adjust the artificial lighting. This helps to lower the energy consumption by ensuring that unnecessary lighting is not left on during daytime hours when naturally lighting is doing its part.

CHAPTER 3

METHODOLOGY

3.1 Project Activities

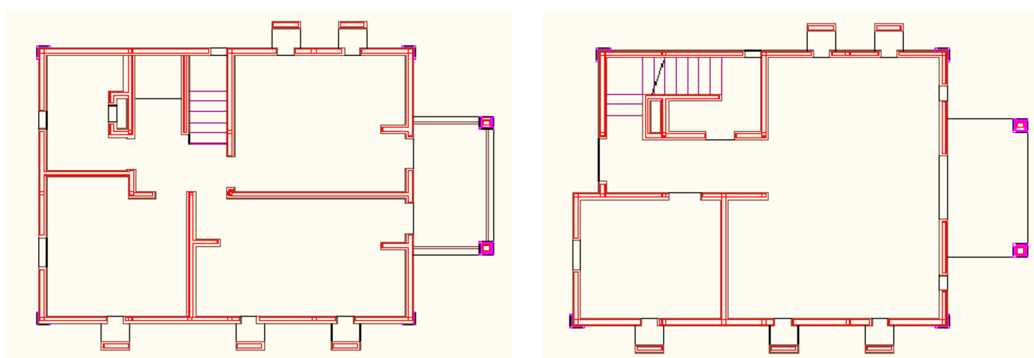
The method used in this study is technical and quantitative in nature. It focuses to study the influences of wall insulation, orientation and location, solar active and passive energy, air conditioning and lighting system to the energy conservation in a Residential House. Environment field data was collected monitoring the temperature and air velocity. A series of environmental data measurement were undertaken through the internet to support the study.

The case study selected was a bungalow house located in Ipoh (4° 36′ 0″ N, 101° 4′ 0″ E). The two storey high bungalow consists of four bedrooms, four washrooms, living area and a kitchen area to be used for this study.

For analysing the parameters, all data collected is transfer to TRNSYS software to tabulate thermal configuration.

FIGURE 2: Basic residential house in Malaysia

FIGURE 3: Plan layout for double-story house



Ground Floor **First Floor**

FIGURE 4: Simplified Floor Plan

3.1.2 Procedure/ Steps:

1. The concept- One must understand the fundamental principle of energy such as heat transfer and energy conversion and management.

2. The building- As discuss in previous section, understanding the whole building function is important in order to simulate the energy conservation. Each component used must be justify by understand its function properly. In order to enhance the energy conservation its functionality, choice of component can be vary. For instance, when component is not offer in TRNSBuild, similar applicable component can be used to it. Besides, calculation part play important role for determine the exact data needed to be inserted into TRNSBuild.

3. Parts/ Component- List down all necessary components as material such as solar collector and weather data required. It is important because incomplete data will cause inaccurate of the program. As discuss above, there are a number of factor which affect the design of the system, thus a detail analysis and calculation is needed in this section.

4. Build Simulation- After complete the data manipulation and analysis proceed to build the prototype according to the design. Bear in mind, no design will work at first time, thus a lot of effort and hard work is needed in order to complete to energy conservation system.

3.2 Gantt Chart

A well planned project Gantt Chart is developed to keep the author on track for the completion of Final Year Project.

Final Year Project 1 and 2

Item / Week	FYP1							FYP2						
	2	4	6	8	10	12	14	2	4	6	8	10	12	14
Theory research & Literature reviews	■	■	■											
Collection of data			■	■	■									
Trial modelling of simulation						■	■							
Modelling of simulation with data collected							■	■	■					
Validation of model										■	■			
Coding troubleshooting and modification											■			
Simulation improvement											■	■	■	
Program finalized & presentation													■	■

■ Development

3.3 Tools Required

TRNSYS will be used to build the program/application for this paper. It is used primary to simulate the thermal energy system. The software has the advantages which are able to tabulate all data needed and an ideal software to simulate energy conservation in buildings.

The require data is collected as the input parameters inside TRNSYS Simulation Program. The data needed such as weather data, volume of the building, U-value of the material can be obtain through the internet and journals. In order to achieve a successful evaluation of all the system, several runs should be conducted and the results needed to be interpret and validate with current journals related.

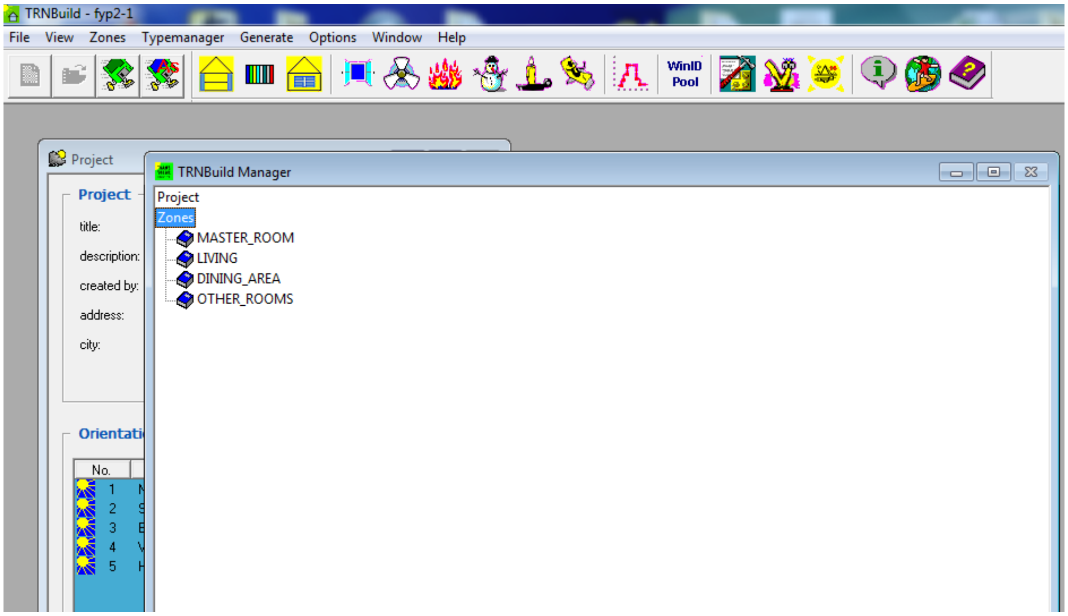


FIGURE 5 : TRNSYS TRNBuild used for simulation

3.4 Key Milestones

This project should be defined in detail for ease understanding and work can be done on time.

Problem Statement and Objective of the project

Identify the purpose and main aim and target of this project to overcome the problem

↓

Background Study

Understand and differentiate work and analysis done by previous research by other related to the project

↓

Literature Review

Gather and analysis information which have been carried by others from various sources such as journals and publish articles and understand the principle and theory which applicable in the project

⇩

Identify Tools and Instrument Needed

List all the necessary tools and instrument for achieve this project

⇩

TRNSYS Process

Identify steps and main objective of design work that need to be investigated and gather all result from system

⇩

Data Analysis and Validation

Results obtained are analysed and interpreted throughout the process and relate to our main objective and studies.

⇩

Documentation and Reporting

This project will be documented and reported in detail for further and future analysis for improvement. Recommendations and suggestion that can be further studied in the future will also be discussed.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Project Simulation Flow

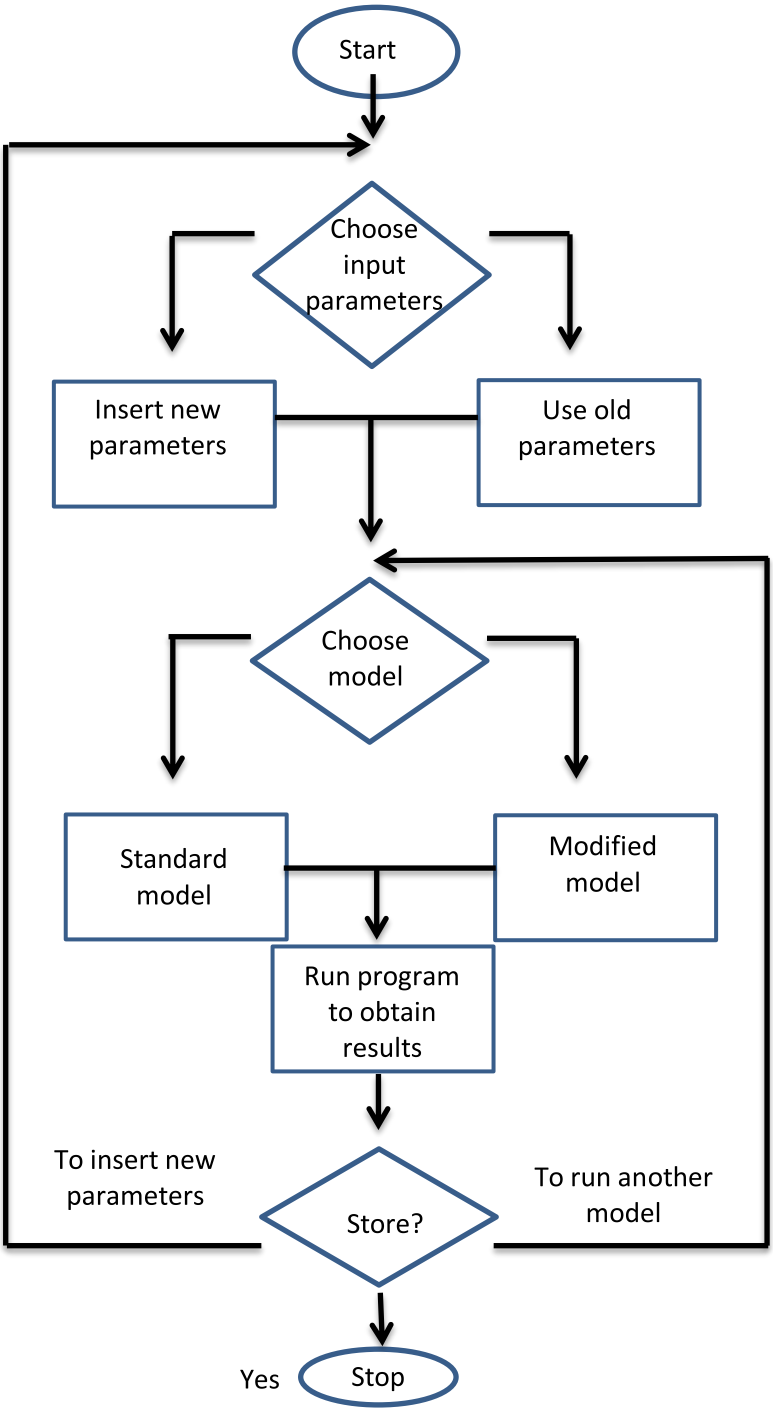


FIGURE 6- Program Flow chart to run the models

4.1.2 TRNSYS PARAMETERS

Data configuration for building energy conservation.

Key Points:	Orientation
	Wall Insulation
	Solar Active / Passive System
	Lighting System
	Air Conditioning System

Input Data:	Wall
	Window Area
	Ventilation
	Infiltration

Zoning:	Master Room
	Living Room
	Guest Rooms
	Dining Area
	Kitchen

4.1.3 Input data needed by TRNSYS

TABLE 1- Input Data

TRNSYS required data	Input data
Floor Plan Shape	Rectangular 14.3m x 8.5m
Wall Area	$81.75m^2$
Roof Area	$84.65m^2$
Window Area	$6.67m^2$
Building Volume	$205m^3$
Window Type	Sliding window with double glazing
Capacitance	500kJ/k
U-Value of the Window	2.7
Internal Shading Factor	9.82
Infiltration air change	0.5
Inside design temperature	26 ºC
Humidity	50%

4.1.4 Building Model cases for thermal analysis

TABLE 2- Building Model

Case	Building cases description	Scenario
1	Building model is using a different types of wall comparing as Standard usage by contractor in Malaysia	Wall Insulation
2	Building model is facing with few direction for investigate orientation of building.	Orientation of the Building
3	Building model is tested with different envelope of wall and window to wall ratio.	Solar Passive System

4.2 Orientation of the Building

The house orientation refers to the direction in which the main entrance is facing towards the source of energy, which is the sun. From the simulation results, whereby other parameters are remain constant for the testing of four orientations: North, South, East and West. By having this information, identification of location of the building which receive the most heat can be detected. With that, designing of air conditioning unit on selected area which receives high heat load energy from the sun where it creates discomfort. Using the house layout, the guest house will be facing East side. During morning it receives the most amount of heat approximately 10.2 KWh and it is advisable to install an air conditioning unit. On the other hand, , it can be found that annual heat loads with South facing orientation is much lower compare to other orientation. The balcony and the living room is the usual hang out place for the residents during the morning session. It is good to have least amount of sun ray facing towards them while the residents can enjoy the comfort.

<u>Grossed exposed wall to Sun</u>

TABLE 3- Area of wall

North size of the wall	49.2 m^2
South side of the wall	50.8 m^2
East side of the wall	65.8 m^2
West side of the wall	66.2 m^2

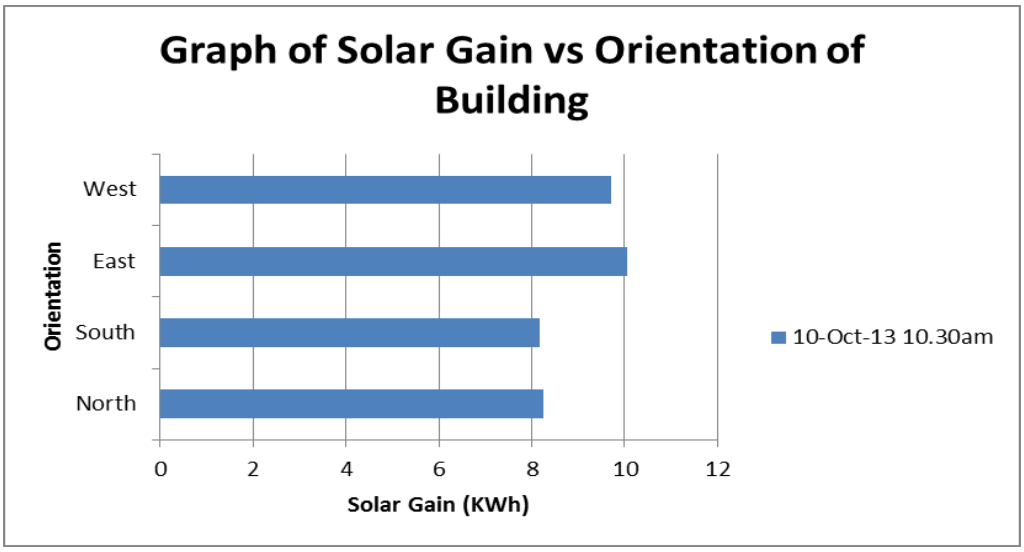


FIGURE 7- Graph of Solar Gain vs Orientation of Building

4.3 Wall Insulation

The table listed below is the common construction element in Malaysia. There are three types being tested in TRNSYS simulation which are envelope with brick wall, envelope with concrete wall and envelope with mud wall. The external walls and internal walls will be manipulated to identify which of the material will produce a lower temperature in the house.

TABLE 4- Envelope with Wall

Envelope with Brick Wall					
External walls		Internal Walls		Roof (from inside to outside)	
Thickness	Material	Thickness	Material	Thickness	Material
20mm	Plaster	20mm	Plaster	10mm	Hanging Ceiling
110mm	Clay Brick	110mm	Clay Brick	15000mm	Air Gap
20mm	Plaster	20mm	Plaster	10mm	All. Foil
				60mm	Ceramic Tiles

Envelope with Concrete Wall					
External walls		Internal Walls		Roof (from inside to outside)	
Thickness	Material	Thickness	Material	Thickness	Material
20mm	Plaster	20mm	Plaster	10mm	Hanging Ceiling
100mm	Clay Brick + Concrete	100mm	Clay Brick + Concrete	15000mm	Air Gap
20mm	Plaster	20mm	Plaster	10mm	All. Foil
				60mm	Ceramic Tiles

Envelope with Mud Block Wall					
External walls		Internal Walls		Roof (from inside to outside)	
Thickness	Material	Thickness	Material	Thickness	Material
20mm	Plaster	20mm	Plaster	10mm	Hanging Ceiling
120mm	Mud Block	120mm	Mud Block	15000mm	Air Gap
20mm	Plaster	20mm	Plaster	10mm	All. Foil
				60mm	Ceramic Tiles

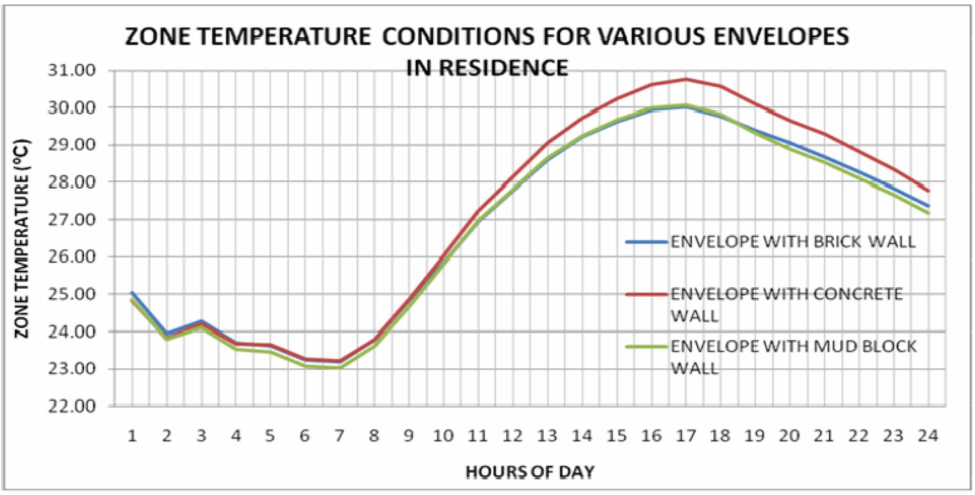


FIGURE 8- Graph of zone temperature with types of envelope

Figure 8 shows the results of zone temperature conditions for various envelops in residence. During the peak of the day which is around 3P.M to 5P.M, envelopes with brick wall produce the lowest temperature in the house which is approximately 30 ºC. It is seen brick wall and mud block wall has similar resistance to heat. However, due to reliability, it is safer to use brick wall as it is common found or purchased in Malaysia.

4.4 Solar Active System

The solar domestic water system have been subjected to many studies and tested for various outcomes in the past. In this research, a set of different parameters is been used to test the maximum energy conservation can be made for residential housing in Malaysia.

The solar collector Type 1b is selected from TRNSYS 16 component libraries. This component shows the number is in series and the characteristic of each module determine the thermal performance of the collector. Equation 1 gives the solar collector the thermal efficiency.

Storage tank volume is $0.5m^3$ which is ideal size for a family usage in residential house. The current total average Malaysia individual domestic hot water usage is 45L/day. Therefore, four occupants are assumed in a typical house total hot water consumption is 180L/day. Since the collectors are installed on the roof, the slope is being the same as the slope of the roof. With that, the collector's azimuth angles are in between 30 degree to 40 degree.

Parametric simulation with TRNSYS have been investigate with different solar collector areas which are $2m^2$, $3m^2$, $4m^2$ and $5m^2$ and different mass flow rate (10kg/h, 20kg/h, 30kg/h, 40kg/h, 50kg/h and 60kg/h).

Since in the previous results stated that the house should face South orientation for ideal energy conservation, the solar collector needed to face South or North as the roofing is design to be flat is that positioning. The results for solar collector efficiency whereby the area of the solar collector and the mass flow rate needed to be matched perfectly according to the environment factor of the residential housing area.

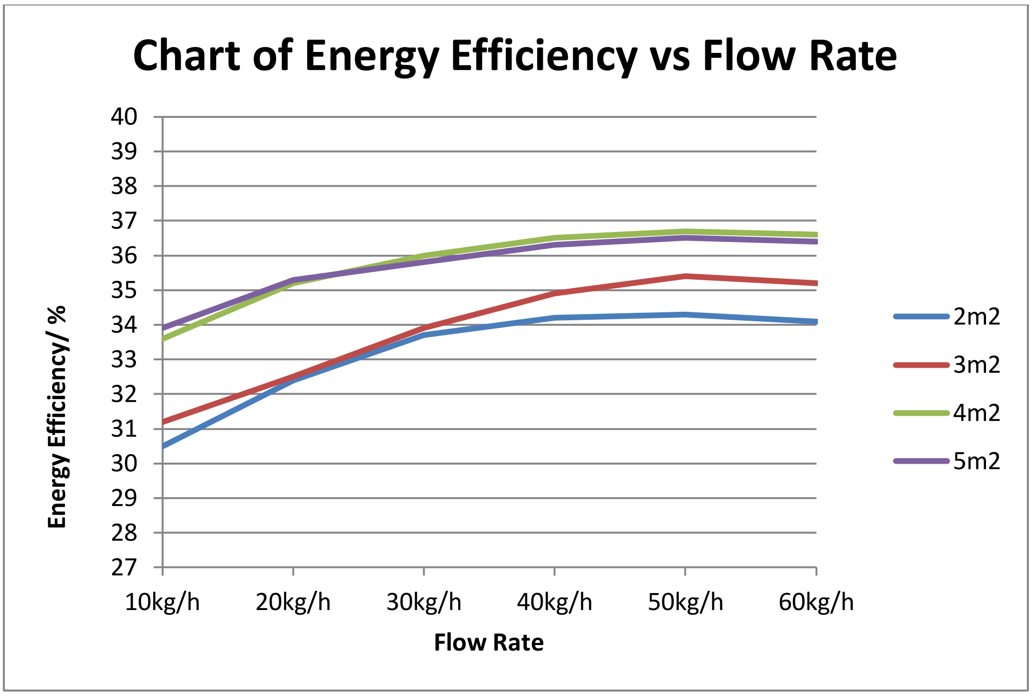


FIGURE 9- Graph of Energy Efficiency vs Flow Rate

Figure 9 shows the energy efficiency by using four sizes of solar collector, the input is inserted to the software with manipulation of the flow rates. It is recommended to use 50kg/h of 4m^2 solar collectors. It is capable to achieve 36% of energy efficiency that able to generate enough hot water for the residents in the house.

Determining the location of the solar collector, it is advisable to place on the North or South of the house roof. This is to maximize solar absorption through morning until evening. With that, we can maximize at least 15% of loss radiation if we installed properly rather than the common installation.

The performance of the solar water heaters not only depends on the solar energy absorbed by the solar collectors, but is also depends on factors such as conduction of collector, convection and infrared radiation, tube spacing inside the collectors and so on. However, one of the criteria to improve the efficiency of the collector is to increase the absorbed radiation by the collector, which emphasizes the importance of proper size and flow rate of the solar collector.

4.5 Solar Passive System

Potential of solar penetration through hot climate, its effect on elevation of the indoor temperature depends on the orientation windows, orientation of the buildings and size of the windows.

Few parameters including U values of external walls, window to wall ratio (WWR) and orientation are investigated in this study. The four different U values of external wall: brick wall, concrete wall and mud block wall are selected to analysed cooling loads for the sample residential house. Four main orientations North, South, East and West have been investigated in this study.

The results of cooling load with the variation in U value and orientation is demonstrated in Figure. The simulation results indicate that with the increase of U values of external wall, cooling loads will decrease.

The parameter will be as followed:

TABLE 5- Building Construction Material

Common Building Construction Material		
Building Elements	Material	U Value
External Wall	Concrete block and brick	0.4
Glazing	24mm double glazing	1.78
Internal Partition	Plasterboard and insulation	0.71
Roof Construction	Concrete tiles and underlay	4.298
Ceiling	Plaster, wood	0.8

Optimum Energy Conservation Material		
Building Elements	Material	U Value
External Wall	Concrete block and brick	0.4
Glazing	19mm double glazing, Suspended plaster board	1.37
Internal Partition	Plasterboard, insulation and air gap	0.51
Roof Construction	Ceramic tiles, reflective foil and air gap	3.156
Ceiling	Plaster, wood, air gap, aluminium foil	1.1

TABLE 6- Results of Solar Passive System

Results		
Energy	Common	Modified
Highest Energy Consumption	8.38kWh/day	7.173kWh/day
Lowest Energy Consumption	7.606kWh/day	6.242kWh/day
Average Energy Consumption	7.789kWh/day	7.037kWh/day
Average Ambient Energy	31.3 ºC	29.8 ºC

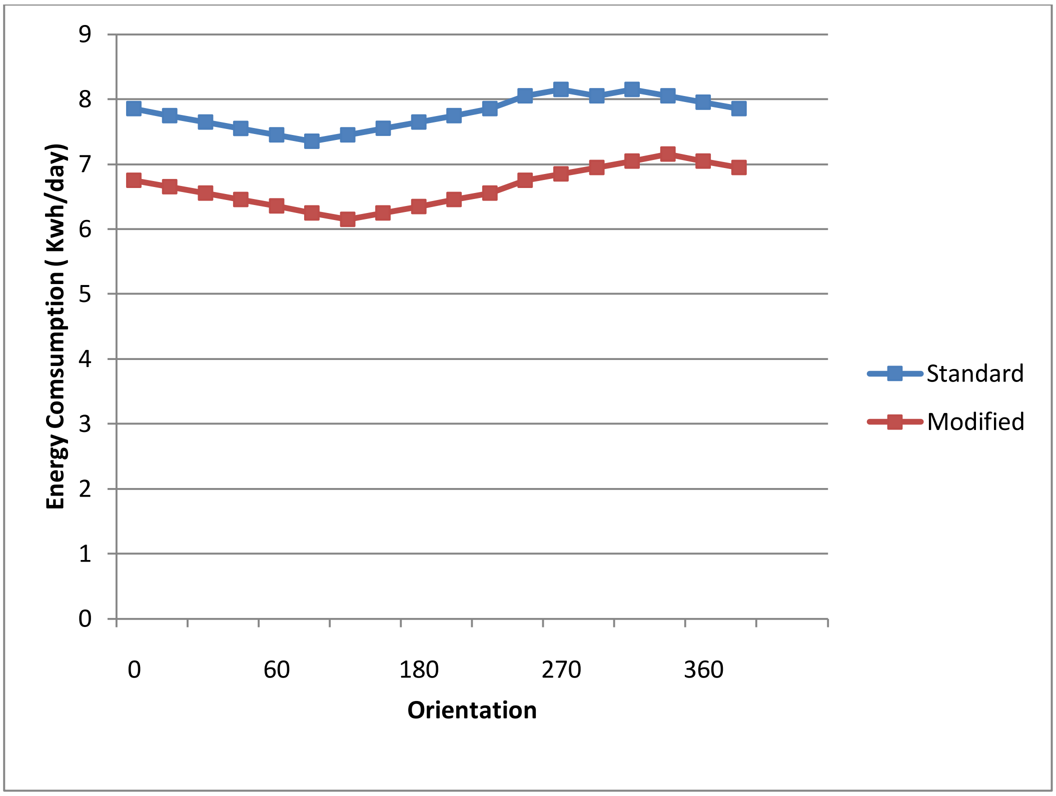


FIGURE 10- Graph of Energy Consumption vs Orientation

Latent Heat

Latent heat is the heat released or absorbed by a body or a thermodynamic system during constant temperature process which the amount of heat exchanged is hidden, meaning it occurs without noticing or temperature vary; for instance, a change of state of matter like condensation of water vapour or melting of ice. Heat is gained or lost in these processes but temperature remains the same throughout.

In this simulation, Ipoh city has a hot and humid weather throughout the year. The temperature along the year is averagely 30 to 40˚C and this indicates that there is no vast temperature difference among them.

Sensible Heat

Sensible heat is a vice versa of latent heat. Heat exchanged by a body or thermodynamic system is noticeable by change of temperature.

It behaves the same characteristic like latent heat. This can be explained as thermal equilibrium has achieved within the building, so basically no heat transfer is noticeable. This can be explained by taking guest’s room as an example. Heat generated by occupants, lighting and heat radiated through windows is infiltrated and ventilated due to air change. By circulating air from outside to the room, the heat outside the building is brought in and it can equalize the heat in the room.

4.6 Lighting System

Lighting designing here mainly refers to the interior lighting of a building. The following formula is usually used to calculate the number of lightings needed in a room.

$$n = \frac{E.A}{\emptyset.N.UF.MF}$$

Where E is the wanted illuminance

A is area

ϕ is lumen of the lighting

N is number of light source in a fitting

UF is utilization factor

MF is the maintenance factor

The utilization factor chart and maintenance factor are usually given. But in practice, the utilization and maintenance factor that are usually used are 0.4 and 0.6. to find the wanted illuminance, we need to use lux calculation. The procedure and a table of lux calculation are as below:

1) Measure the room width (W)

2) Measure the room length (L)

3)Get the room are by multiply the room width and the room length. (A=W x L)

4) Measure the total height (Ht)

5) Measure the suspension height (Hs)

6) Measure the working plane height (Hw)

7) Measure the mounting height (Hm) = (Ht-Hs-Hw)

8) Calculate the Room Index (Kr) =(L.W)/[(Hm)(L+W)]

9) Identify the reflectance ratio for ceiling : walls : floor

10) Identify the numbers of light sources per lantern (n)

11) Check the utilization factor (UF)

12) Identify the maintenance factor (MF)

13) Identify the type of lamp

14) Check the luminous flux per lamp

15) Check the illuminance required(E)

16) Calculate the number of luminaires (N) = (E.A)/(Φ.n.UF.MF)

17) Calculate the number of luminaires along √[(L.N)/W]

18) Calculate the number of luminaires across √[(W.N)/L]

19) Calculate the actual illuminance (E) = (N.Φ.n.UF.MF)/A

20) Check the spacing / Mounting height ratio (<1.5)

TABLE 7- Luminance calculation

Area Width	W	m	8
Area Length	L	m	9
Floor Area	A	m	72
Total Height	Ht	m^2	3.8
Suspension Length	Hs	m	0.8
Working plane height	Hw	m	-
Mounting Height	Hm	=(Ht-Hs-Hw)m	3.0
Room Index	Kr	=L.W/Hm.(L+W)	1.74
Reflectance	Rc	-	0.5
	Rw	-	0.3
	Rf	-	-
No. of light sources per lantern	N	-	2
Utilization factor	UF	-	0.42
Maintenance factor	MF	-	0.8
Type of lamp		-	Fluorescent

Luminous flux per lamp	ɸ	Lumen	2800
Wanted illuminance	E	Lux	150
Calculation of No. of luminaries	N	$(E.A)/$ (ɸ.n.UF.MF)	7
No. of luminaires along	$\sqrt{}[(L.\frac{N}{W}]$	-	4.33
No. of luminaires across	$\sqrt{\left[\frac{W.N}{L}\right]}$	-	2.30
Actual illuminance	E	=(N. ɸ.n.UF.MF)/A	156.8
Check spacing/mounting height ratio	S/Hm	< 1.5	1.0

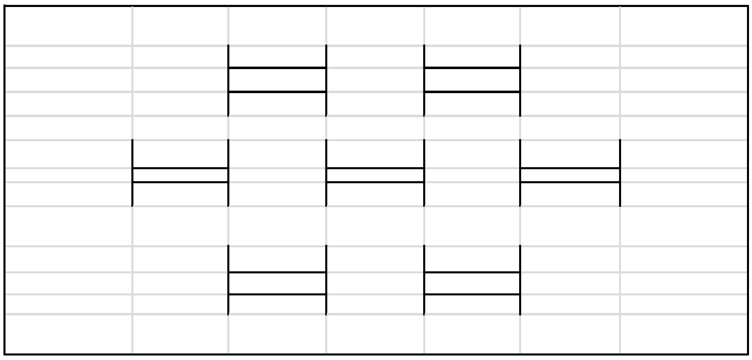


FIGURE 11- Number of Light Fittings

CalcuLuX Indoor 4.0 software

With this software we can get numbers and position of lights easier, compare to hand writing calculation shown. To use this, first we open a New Project, and then select 'Data', 'Room'. After that, we key in the room detail and requirement of illumination. This can refer to Diagram below

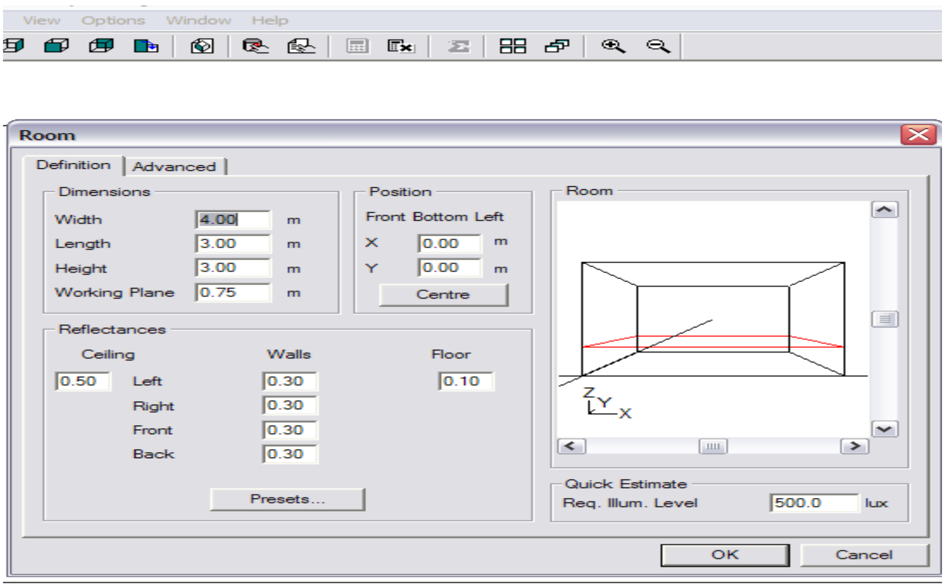


FIGURE 12- Calculux Lighting System 1

After that, go to 'Data', 'Project Luminaries', and then 'Add', 'Phillum', select one of the light use in this case.

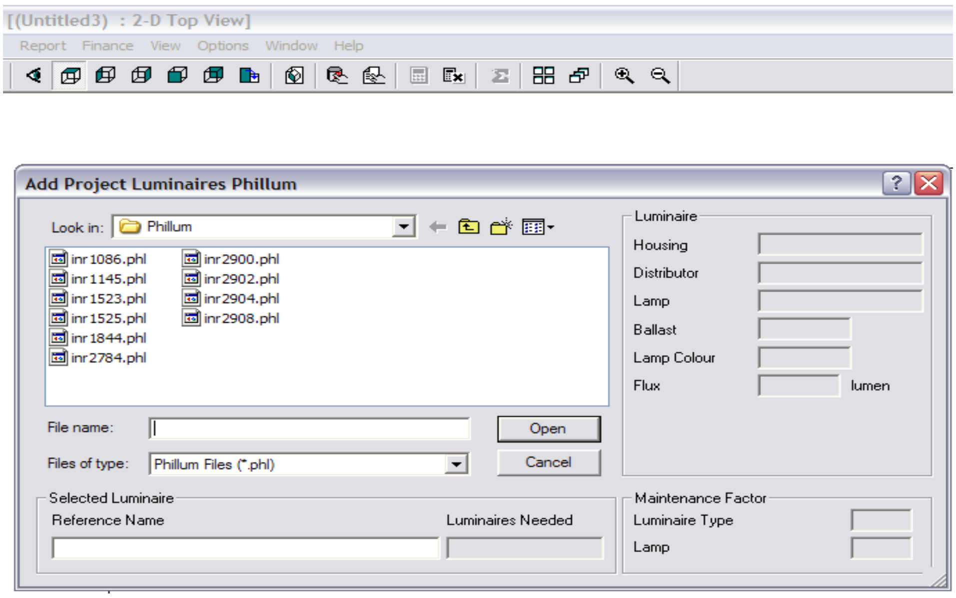


FIGURE 13- Calculux Lighting System 2

After that, select ‘Data’, ‘Arrange Luminaries’. The program then will shows the number and position of the light suit to fit in the room space. With this software, we can easy to arrange the lighting for room and office space.

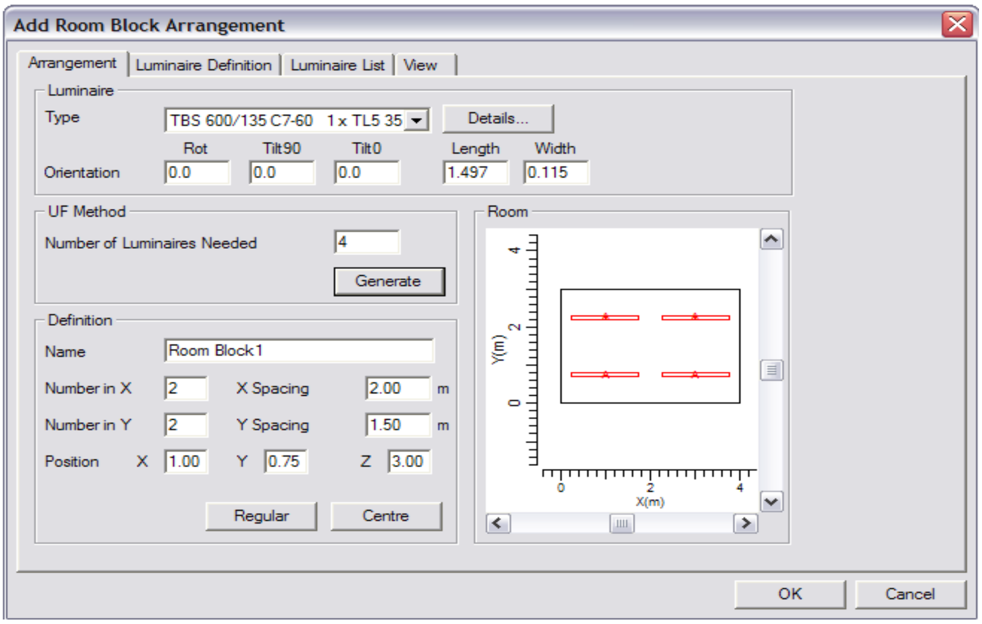


FIGURE 14- Calculux Lighting System 3

Result in 3D view:

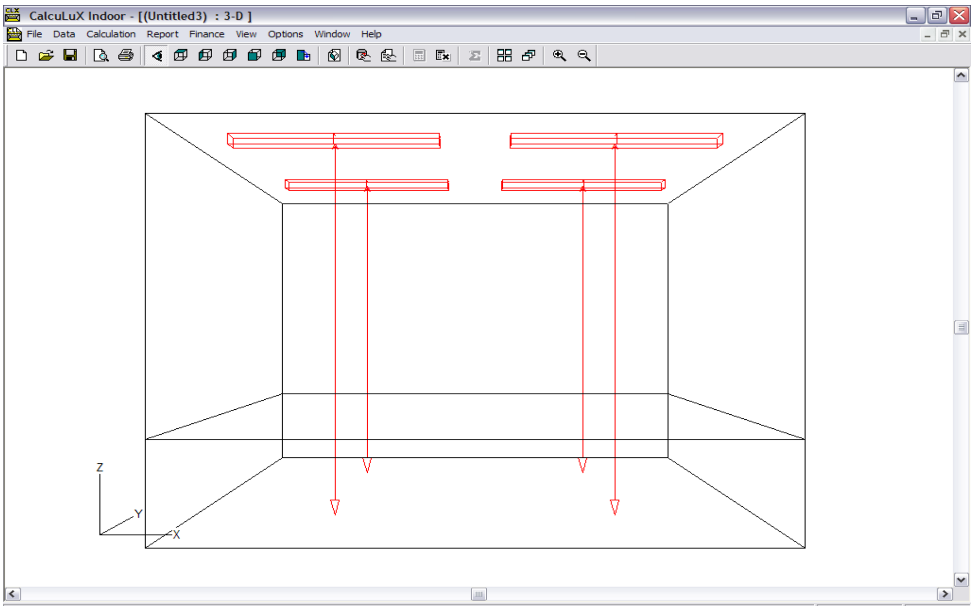


FIGURE 15- Calculux Lighting System 4

4.7 Air Conditioning System

Cooling Load

The components that contribute to the cooling load are taken into account in order to fully utilize the performance of the air conditioning system. It consists of exterior walls, roof and glass, conduction through interior partitions, ceilings and floors, solar radiation through glass, lighting, people and equipment. Heat gain through conduction is calculated using the formula:

Q= U x A x CLTDc

Where Q is the cooling load value (in Btu/hr), U is the overall head transfer coefficient of the exterior surface wall, A is the area of the surface wall and CLTDc is the corrected value of Cooling Load Temperature Difference. CLTDc value can be obtained using ASHRAE 1989 where :

CLTDc = CLTD + LM + (78 – Tr) + (Ta – 85)

Where LM is the latitude and month CLTD correction, Tr is the indoor relative temperature and Ta is the outdoor relative temperature. The glass is not included in LM calculation. However, bricks wall, roof and doors are needed.

Then, heat gain through solar radiation is calculated by using the formula:

Q = SHGF x A x SC x CLF

Where Q is the solar cooling load value, SHGF is the solar head gain factor, A is the glass area that is exposed directly to the sun light. SC is the shading coefficient and CLF is the cooling load factor.

Heat gains from lighting are equally important for contributing cooling load factor. The Ballast Factor is the key for head losses in the ballast in fluorescent lamps or other types of lightings. Typical value of Ballast Factor is 1,25 for fluorescent lighting. The load calculation is based on the formula:

Q = W x BF x CLF

Where Q is the load, W is the lamp wattage, BF is the ballast factor and CLD is the cooling load factor.

4.7.1 Calculation

Reference location is taken at Ipoh with the latitude of 4.22 N. Design dry bulb temperatures and wet bulb temperature is 32.5 degree C and 26.9 degree C respectively. For the indoor design condition, dry bulb temperature is 24 degree C with relative humidity of 50%. From psychometric chart, humidity ratio value is obtained for both outdoor and indoor design. For outdoor design condition, humidity ratio is at 0.0142kg of vapour/kg of water while for indoor condition, humidity ration is at 0.066kg of vapour/kg of water. Using the formula stated below, the capacity of air conditioning can be calculated as followed.

Floor Area of Room
The amount of cooling required depends on the area of the room. To calculate the area in square metres:

Room Area BTU = Length (m) x Width (m) x 337

Window Size and Position
If, your room has no windows, you can ignore this part of the calculation. If, however there are windows you need to take the size and orientation into account.

South Window BTU = South Facing window Length (m) x Width (m) x 870

North Window BTU = North Facing windows Length (m) x Width (m) x 165

If there are no blinds on the windows multiply the result(s) by 1.5.

Add together all the BTUs for the windows.

Windows BTU = South Window(s) BTU + North Window(s) BTU

Occupants
You will have to take that into account people who normally working in the space. The heat output is around 400 BTU per person.

Total Occupant BTU = Number of occupants x 400

Equipment
Clearly most heat in a room is generated by the equipment. This is trickier to calculate that you might think. The wattage on equipment is the maximum power consumption rating, the actual power consumed may be less. However it is probably safer to overestimate the wattage than underestimate it.

Equipment BTU = Total wattage for all equipment x 3.5

Lighting
Take the total wattage of the lighting and multiply by 4.25.

Lighting BTU = Total wattage for all lighting x 4.25

Total Cooling Required
Add all the BTUs together.

Total Heat Load = Room Area BTU + Windows BTU + Total Occupant BTU + Equipment BTU + Lighting BTU

This is the amount of cooling required so you need one or more air conditioning units to handle that amount of heat.

TABLE 8- Heat Gain Parameters for Air Conditioning System for Living Area

Heat Source	Heat Gain (Btu/hr)
Floor Area	18260
Window	9820
People	2400
Lighting	3360
Equipment	2820
Total	36600

Specification (R-410A)
Ceiling Cassette Type - Y5CK-A Series

MODEL			INDOOR UNIT	Y5CK20A	Y5CK25A
			OUTDOOR UNIT	Y5SL20C3	Y5SL25C3
TOTAL COOLING CAPACITY			Btu/h	18,500	20,000
			W	5,422	5,862
TOTAL INPUT POWER			W	1,700	2,003
TOTAL RUNNING CURRENT - 1Φ [3Φ]			A	7.5	8.90
POWER SOURCE			V/Ph/Hz	220-240 / 1 / 50	
REFRIGERANT TYPE				R-410A	
REFRIGERANT CONTROL (EXPANSION DEVICE)				OUTDOOR CAP. TUBE	
CONTROL	AIR DISCHARGE			4 WAY AUTOMATIC LOUVER (UP & DOWN)	
	OPERATION			WIRELESS OR WIRED MICROCOMPUTER REMOTE CONTROL	
FAN					
	AIR FLOW	HIGH	l/s / CFM	349 / 740	368 / 780
		MEDIUM	l/s / CFM	297 / 630	311 / 660
		LOW	l/s / CFM	283 / 600	283 / 600

FIGURE 16- Air Conditioning Technical Data

We can usage one unit of Y5CK20A and Y5CK25A which give 16,500 and 20,000 Btu/h respectively. In total, the total cooling load is higher than required. With this, the cooling capacity in the area can be achieved

CHAPTER 5

CONCLUSION

A small portion of the residential home has been tested for the pre-run simulation. This is to ensure the simulation works perfectly before starting the full scale simulation. TRNSYS provides a real-time condition of a transient system in a faster and inexpensive way than experiment. In this simulation, it helps us to understand the energy distribution of a residential house in Malaysia. It is found that heat loads with South facing direction is much lower compare to other direction with approximation 8.15KWh. With South facing direction, the solar collector will be faced aligned North or South to have maximum solar absorption. Data shows solar collector of 4m2 with 50kg/h is highly recommended. Wall insulation using brick wall is better than concrete wall as it can provide more heat resistance. Solar passive system which related to orientation and wall type is tested and better configuration is confirmed. Air conditioning and lighting system is designed with industrial calculation for better configuration.

With the graph plotted on a specific room, a suitable HVAC system can be designed and put into use with the conservation of energy which been fully utilised on carry out experiment. Dry and humid weather is common in Malaysia, with only considerable cooling at night. This makes the HVAC system an indispensable part of the house, and a thorough understanding of the expected condition can only be achieved by simulating it using TRNSYS. Modifications can be added to the house to control the temperature and humidity to the occupants' comfort level based on the outcome of the simulation.

RECOMMENDATION

It is recommended to have an analysis of conservation of energy using TRNSYS which related to economy wise. With that, the research will be much more comprehensive and suitable to the society. Furthermore, using economic value, we could plot the timeline of return of investment representing the alternative energy. Graphical data can be introduced to TRNSYS in order to tabulate all data of every part of the house. This is to show the details layout of energy flows and how to conserve it. Using the data of Semi-D housing, we could develop the same concept towards other types of building such as terrace house, bungalow and apartment. With that, the society can always have a guidance whenever they face any difficulties related to conservation of energy. Lastly, it is advisable to have more literature review regarding conservation of energy related to Malaysia's weather. Every country has their own climate. In order to have a more accurate data, using the suitable method proposed by researcher that observed and analysed the Malaysia's weather.

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