ENERGY EFFICIENCY MEASURES ON TWO DIFFERENT COMMERCIAL BUILDINGS IN MALAYSIA

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Abstract
Buildings consume almost the highest energy in Malaysia, and the highest energy consumption comes from electricity. In order to reduce energy consumption in the commercial buildings, energy efficiency measures need to be done based on factors that affect energy consumption in the building. In this paper, the energy consumption of two commercial buildings are taken as a case study, and a number of energy cost saving measures were proposed based on the energy audit. The primary objective of this study is to obtain the minimum years of return of investment for two different commercial buildings through energy efficiency measures. In this case study, energy prediction is added and its results are used to determine how much saving could be obtained. The methodology used for prediction of energy consumption is autoregressive integrated moving average, and its performance was compared with linear regression and artificial neural network. The results showed that the most accurate method with the highest cost saving is autoregressive integrated moving average. Finally, building energy index was calculated, and the results showed that the minimum years of return on investment is two years if the investment is RM 499,539. For future work, other factors such as the number of equipment should be included in the prediction analysis to obtain more accurate results.

Keywords: ARIMA; artificial neural network; building energy index; Energy Cost Saving Measures; energy prediction.

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INTRODUCTION

The increment rate of gross domestic product (GDP) and electricity consumption had been consistent until the mid-1990s where Malaysia experience a slump in GDP, but the electricity consumption continued to increase until now. Increasing of electricity consumption would bring negative impact to the environment where carbon dioxide emissions would increase excessively. Figure 1 shows the increase of carbon emissions per capita in Malaysia compared to other two ASEAN countries. The carbon emissions in Malaysia is the highest compared to Thailand and Indonesia.

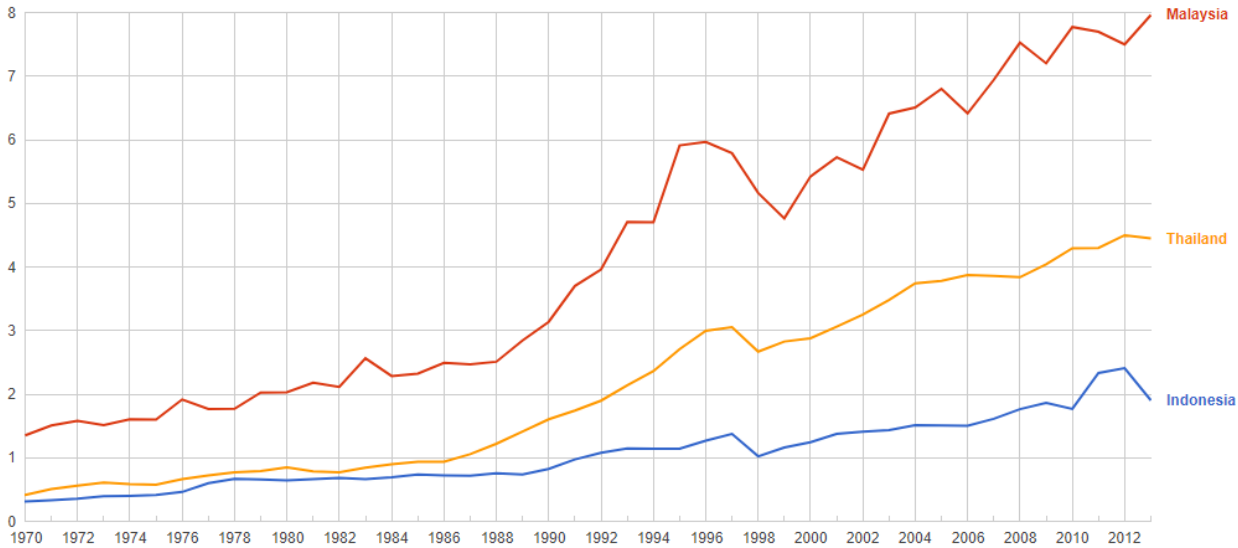

Figure 1: Carbon emissions per capita for Malaysia compared to Indonesia and Thailand (Source: World data)

The increasing of carbon emissions is due to 82% of Malaysia's electrical energy used is generated by fossil fuels as their source of energy. Table 1 below shows that Malaysia is still dependent on fossil fuels to generate electricity compared to Europe percentage that already used water and renewable energy to generate electricity.

Table 1: Production capacities per energy source (Source: World data)

Energy source	Malaysia Total	Malaysia percentage	Europe percentage	Malaysia per capita	Europe per capita
Fossil fuels	239.78 bn kWh	82,1 %	49,4 %	7,688.39 kWh	8,039.12 kWh
Nuclear power	0.00 kWh	0,0 %	7,3 %	0.00 kWh	1,189.73 kWh
Water power	40.89 bn kWh	14,0 %	23,3 %	1,311.05 kWh	3,795.70 kWh
Renewable energy	11.68 bn kWh	4,0 %	15,9 %	374.59 kWh	2,584.00 kWh
Total production capacity	292.06 bn kWh	100,0 %	100,0 %	9,364.67 kWh	16,287.32 kWh

To solve this problem, Malaysia has introduced energy efficiency in 10th Malaysia plan. Beside promoting renewable energy as energy sources to generate electricity, energy efficiency is one of the practice to reduce electricity consumption. Building energy efficiency is one of the solutions since commercial buildings consume 40% of energy consumption in the most countries. A well-designed energy efficiency building maintains the best environment for human habitation while minimizing the cost of energy.

For some buildings that are designed without energy efficiency features, these retrofitted buildings optimize their energy consumption by using other methods such as thermal energy storage, energy management system (BEM) and energy efficiency analysis. All these methods were applied regarding cooling, heating, lighting, pump, chiller and more. Malaysia's standard also as important as the method since all the specification of the feasibility of energy efficiency design standards need to be followed. This is because energy is not a fixed cost and it may be one of the most controllable inputs. Energy consumption in buildings is measured based on the Building Energy Index (BEI). According to the study done by Zainordin and Abdullah (2012), the average of BEI for Malaysia and Singapore is 269 kWh/m^2/year and 230 kWh/m^2/year respectively compared to South East average BEI which is 233 kWh/m^2/year. Later, the guidelines were renamed and revised as the Malaysian Standard MS 1525:2007. This standard aimed to encourage the application of renewable energy sources, pollution and energy consumption while maintaining comfort, health, and safety of the building occupants.

This study aims to optimize energy consumption of two office buildings named Skywarth and Skymage located in Klang Valley, Malaysia. The optimization is done by analyzing energy usage in the buildings through the energy audit. From energy audit, data such as electricity bills, building information and office equipment will be collected. Then, the pattern of data will be analyzed to determine which systems or applications that are consuming the highest electricity. There are several loads and applications in the office building that consume most of the energy such as heat ventilation air conditioning system (HVAC), lighting system, office appliances and others. It had been stated from the previous study that HVAC system contributes the highest in the energy consumption due to the equipment such as chiller, air handling unit (AHU), boilers, pump and supply fans uses a lot of electricity to operate it. Furthermore, most of this equipment operates at a longer time compared to others. In this study, all factors that contribute to energy consumption were studied by using a fishbone or Ishikawa diagram.

The data from the energy consumption will be used as an input for energy prediction. The method proposed for energy prediction in this study is autoregressive integrated moving average (ARIMA), while the other two methods which are linear regression and the artificial neural network will be applied for comparison. By referring to the prediction of the energy, energy usage of these two buildings can be determined and by optimizing energy usage of the system, the energy can be saved. Hence, by comparing the energy saving with before energy optimization is applied, the percentage of energy efficiency can be calculated. Based on the energy efficiency, the return of investment time can be determined for both Skywarth and Skymage buildings.

The rest of this paper is organized as follows, where the discussion is started with a discussion on previous studies. The factors of energy consumption in the building, research framework, energy consumption information, potential energy efficiency approach on these two buildings and mathematical tools for energy prediction are presented in Section 3. After that, the discussion will be continued on results of this study which consists of energy prediction and comparison with other two methods, prediction error and building energy index calculation before it ends with the conclusion and discussion on the potential future research.

LITERATURE REVIEW

There are a number of case studies had been done involving energy consumption for a commercial building in Malaysia although every study highlighted different problems. A study done by Zeeshan (2014) emphasized on the major part of energy utilization which is HVAC (heating, ventilating and air conditioning) system, lighting system and office appliances. CLTD/CLF (cooling load temperature difference/cooling load factor) software had been used for calculation, and then, these parameters were optimized according to the building requirements. The process of this study started with a collection of all relevant building data such as architectural drawing, building location, climate, air flow rate, lighting, office equipment, temperature and electricity bills. This study also used electricity bill to analyze the trend of the electricity consumption. In this study, the building was divided into 11 floor areas to analyze which area consumes maximum energy so that the potential for energy conservation can be determined. The results showed that 33.25% energy could be saved if these methods were implemented.

Another similar work is from a research study on energy analysis of a building by using the artificial neural network (Kumar and Aggarwal, 2013). This study emphasized on the methodology where various artificial neural networks were used to predict the heating and cooling load, indoor air temperature, HVAC system and prediction of energy. A comparison was made between these different types of networks such as recurrent neural networks, auto-associative neural network, and general regression neural network to obtain the most accurate results. The idea from Kumar and Aggarwal is adapted to this study also of optimization to obtain more energy saving.

A study from Hamzah Abdul-Rahman, Chen Wang and Mei Ye Kho (2011) discussed on the potentials for sustainable improvement in building energy efficiency. Their case study was based on tropical zone countries such as Malaysia. Based on their investigation, they found that saving can be achieved through improvements in building orientation, shading, film coating, infiltration and applications of daylighting. Although their study more on energy management, but it provides some energy cost-saving measures (ECMs) that can be implemented in other studies.

Lastly, a case study on the relationship of energy consumption with occupancy in the academic building (Gul and Patidar, 2014). This research is one of the famous studies as it is referred to study the factors of energy consumption especially related to occupancy. In this research, it stated that commercial building, primarily office, and university building are classified amongst the building that consumes the highest energy. However, the academic building in university and school and hospital are different with office building since its occupancy is not fixed. This research helps in determining factors of energy consumption in the building that will be used in research methodology before an analysis can be performed.

For energy prediction, three studies were reviewed. First, a review paper of artificial intelligence based building energy prediction with a focus on ensemble prediction models by Wang and Srinivasan (2015). This paper reviews all the artificial intelligence methods that have been used in energy prediction such as multiple linear regression, artificial neural networks, support vector regressions and ensemble prediction models. All the methods listed in this study has its disadvantages and advantages. Thus, researchers have to choose the appropriate method in their study. Since this paper is only a review paper, thus to test which method is more effective, the method needs to be applied into real practice.

Another study that is involving the prediction of building energy consumption was done by Tardioli et al. (2015) wherein their study; they applied data-driven approaches. Their study was focusing on analyzing energy at the urban scale and doing so, all the available information and the level of granularity of the data must be evaluated. The combinations of different methods are employed at a large scale to predict energy consumption and to overcome the missing data. The conclusion from this review paper found that some notable data driven models such as artificial neural networks and support vector machine are still not employed at a large scale to provide detailed information on the building stock.

Lastly, latest study on building stock energy prediction where the focus was on stochastic modeling. Lim and Zhai (2017) reviewed the latest advanced techniques in modeling building stock energy consumption including all approaches whether its top-down or bottom-up approaches. This paper listed down the advantages and disadvantages for each primary method. However, the focus of this review paper was more on bottom-up than top-down since most of these top-down models utilize an interaction between energy sectors and other economic indicators so that it can reflect the impact of social-economic policies. It is also stated in this paper that it is not easy to study the effects of specific technological advances and policies since the top-down models are dependent on historical data. For the bottom-up model, statistical methods had been applied and most of the statistical models are based on the regression models as cited in this paper. It is known that regression models are the most popular method not just based on the advantages listed in this paper, but it is more convenient based on some industrial people's opinion which is why this method is applied in our study. Stochastic models that had been reviewed in this study are Monte Carlo, Bayesian and Markov Chain Monte Carlo (MCMC). From those three models, this study concluded that all these three models able to reduce energy consumption in the building stock without historical data but there are two disadvantages which are computational efficiency and capability of covering the uncertainties. Due to those disadvantages, a simple time series method which is autoregressive integrated moving average (ARIMA) is proposed in our study.

FACTORS OF ENERGY CONSUMPTION IN THE BUILDING

In Malaysia, the highest energy consumed by commercial buildings is electricity, especially for the commercial office building. According to the Electricity Supply Act 1990 under Efficient Management of Electrical Energy Regulations 2008 section 1(1A), any installation which receives electrical energy from a licensee or supply authority with total electricity consumption equal to or exceeding 3MWh as measured at one metering point or more over any period of six consecutive months are required to conduct an energy audit by an authorize individual known as Register Electrical Energy Manager or REEM (Energy Commission). The energy consumption in the office or commercial building is due to some significant factors within the building itself and the environment surrounding it.

In this research, the only factor that was taken as an input for energy prediction is the outside temperature since there were difficulties in obtaining data for the rest of the factors. Besides, the other factors only have a small effect towards the energy consumption since the type of the building for this research is a commercial building. A fishbone or Ishikawa diagram is created to identify all the factors that contribute to energy consumption. Based on the figure 2 below, six factors affect energy consumption in the building.

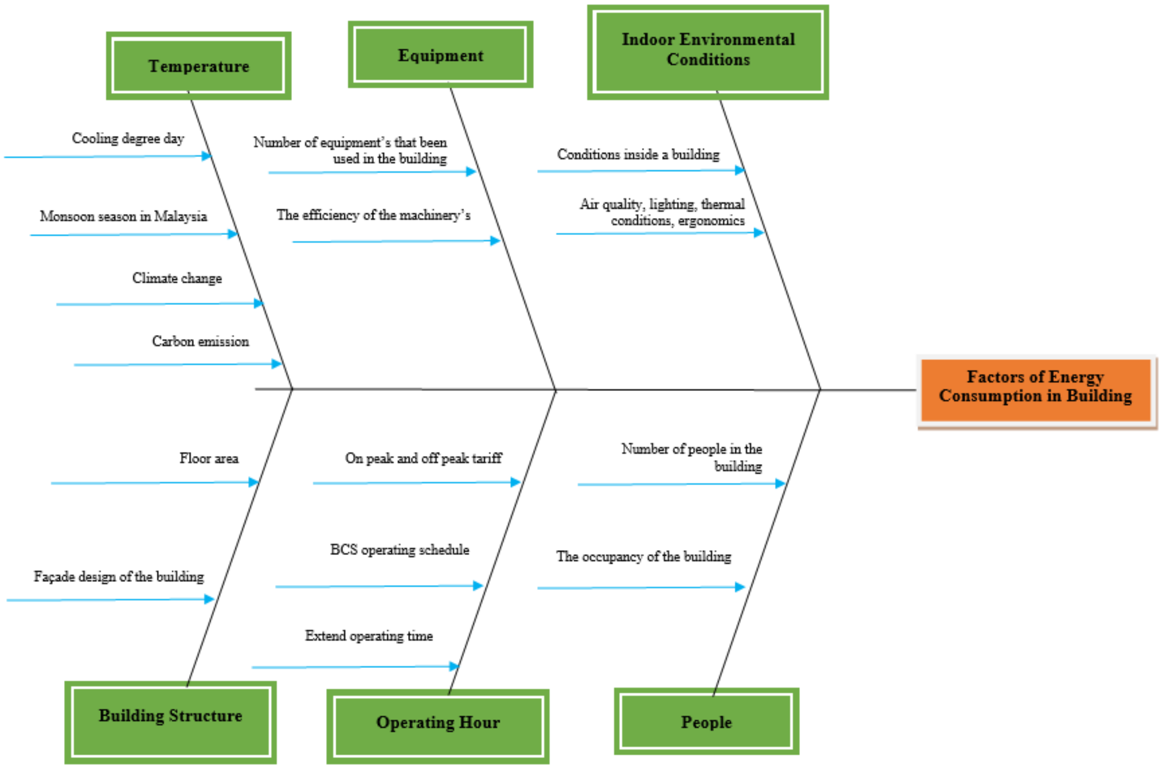

Figure 2: Energy consumption factors

The first factor is the number of equipment that has been used in both Skywarth and Skymage buildings. The equipment that been identified as significant energy consumption is the chiller, water pump, fan, motor and most other heavy mechanical equipment. This type of equipment consumes a significant amount of energy as most of the equipment consist of motor and heating or cooling process (Westphalen, 1999). As the number of equipment increases, it also increases the number of loads which then increase the consumption of electricity to operate the big load in the buildings.

Temperature is the second significant factor since Malaysia is not a four season country and cooling as thermal comfort is a very demanding among the Malaysian. In this research, the data for outside temperature was taken from Malaysian Meteorological Department. People also among the factor that lead to the increasing or reducing of energy consumption in the building. The reason for this fact is as the number of occupancy increase in a particular building, the demand of the usage will also increase which mean the need for the electricity will be more compared to the normal condition. However, this factor is not included in the input variables as it has less effect on the commercial building that usually has a fixed amount of people in the building. This factor only affects the energy consumption at the early stage as the number of occupants in the building will increase until a certain period where it will be fixed. This factor will be included as an essential variable if the type of the building is the hospital, school, university and other building that have an unfixed number of occupancy (Mahusin and Baharun, 2014).

Operating schedule in a building is controlled by the Building Control System (BCS) to operate. If all of the equipment in the building operating at the same time in the morning, it will increase the maximum demand rapidly. Instead of turning on all of the equipment at the same time, it is more efficient to start the operation of the equipment by having a delay time between each equipment. This technique can help to reduce maximum demand which will reduce the energy usage during the start-up of the building. This technique also helps to reduce the electricity bill as the utility supply will charge on the highest maximum demand in their tariff calculation as Tenaga National Berhad need to cater for this peak load whenever required by the customer. Since electricity cannot be stored, there must be sufficient available generation, transmission and distribution capacity to meet the highest demand.

The facade is another factor that affects the energy consumption. The floor area of a building will affect the energy consumption by the amount of energy usage. The bigger the floor area, the more energy will be used to fulfil the need (Zeeshan, 2014). However, this factor is related to the other factor which is people. Even when the area is big, if the occupancy in the building is less, there will be no need to supply electricity to the non-occupant area. The other factor in term of the building structure is the façade design of the building itself. This factor has been considered during the design of the building process. For example, the window shading can affect energy consumption if the sunlight gets through since the heat is increasing and it will need more electricity to fulfil the comfort level (Zainordin and Abdullah, 2012).

Lastly, a factor that recently been added by International Energy Agency (2013) which is indoor environmental conditions. Indoor environmental conditions encompass the conditions inside a building such as air quality, thermal conditions and their effects on occupants. Energy consumption will be increased if the indoor environmental conditions are not good. For example; the existence of dust in the air will cover some equipment inside the building which then will increase the load of that equipment.

RESEARCH METHODOLOGY

Data Collection

Before analysis can be performed, the building details or building profile area need to be identified as this information are essential. This case study consists of two different buildings named Skywarth and Skymage building. Skywarth is 33 storeys high while Skymage is 50 storeys high. Both buildings have two types of energy supply which are electricity and thermal energy (chilled water). The electricity provider is Tenaga Nasional Berhad (TNB) while the chilled water is supplied by Gas District Cooling Sdn Bhd (GDC). This causes the energy supply to the building is split into two parts. According to the energy audit, both buildings obtained 100% energy consumption.

Based on the energy audit conducted, several measurements taking into consideration to obtain full analysis to help us determine which part of the building consume the highest energy. The measurement of the energy accounting including the number of all lamp (indoor and outdoor), the AHU reading, the number of lux, carbon dioxide measurement and others measurement that related to electricity consumption. The details of energy accounting for electricity consumption without considering the chilled water data for both buildings are shown in the tables below:

Table 2: Details on annual energy consumption for Skywarth building

Building Services	Annual Energy Consumption (kWh)	Percentage
Indoor Lighting	2,108,177.9	37.4%
Air Handling Unit	1,376,106.5	24.4%
Mechanical Ventilation	1,047,418.3	18.6%
Office Equipment & Small Power	459,491.3	8.1%
Chilled Water Pumps	337,719.05	6.0%
Elevators	116,900.0	2.1%
Air Cooled Split Unit	86,023.2	1.5%
Fan Coil Unit	72,207.2	1.3%
Mechanical Pump	27,156.0	0.5%
Compound and Façade Lighting	8,394.7	0.1%
Total Electrical Energy Consumption	**5,639,594.0**	**100.0%**

Table 3: Details on annual energy consumption for Skymage building

Building Services	Annual Energy Consumption (kWh)	Percentage
Indoor Lighting	2,590,421.7	34.4%
Air Handling Unit	1,202,379.8	16.0%
Mechanical Ventilation	805,146.2	10.7%
Office Equipment & Small Power	1,140,783.5	15.1%
Chilled Water Pumps	242,262.75	3.2%
Elevators	871,576.2	11.6%
Air Cooled Split Unit	79,540.8	1.1%
Fan Coil Unit	194,824.6	2.6%
Mechanical Pump	257,477.4	3.4%
Compound and Façade Lighting	148,482.0	2.0%
Total Electrical Energy Consumption	**7,532,895.0**	**100.0%**

Methodologies on Energy Prediction Applied in This Study

Autoregressive Integrated Moving Average

Autoregressive integrated moving average (ARIMA) method is selected to be applied in this analysis because it allows a deeper understanding of the data and can be used to predict future points in the series. Before getting on the cycle, the first step to take is to examine the time plot of the data and to judge whether it is stationary or not. Lots of time series are nonstationary, and ARIMA model supports the type of nonstationarity by simple differencing. In fact, one or two levels of differencing are frequently enough to reduce a time series. The three parameters in the ARIMA model are the number of differences, *d*, the number of autoregressive, *p*, and the number of moving average, *q*. A general model of ARIMA is written in the form:

$$x_t = A + \varphi_1 x_{t-1} + \varphi_2 x_{t-2} + \ldots + \varphi_p x_{t-p} + b_t - \theta_1 b_{t-1} - \theta_2 b_{t-2} - \ldots - \theta_q b_{t-q} \quad (1)$$

where t is the periodic time, x_t is the numerical value of observation, φ_i for i = 1, 2, …, p are the autoregressive parameters, θ_j for j = 1, 2, …, q are the moving average parameters, and b_t is the shock element at time t.

In this analysis, the active power (kWh) will be the forecasted variable. The following procedure is used to model an ARIMA, whereby using Time Series Modeler in the SPSS software, the best ARIMA model can be obtained. From SPSS, the best ARIMA model that should be used based on the data analysis is ARIMA (0,1,0). This model allows prediction of energy consumption to be obtained and these results can be used in building energy index calculation (Ramli and Abdul Hamid, 2017).

Artificial Neural Network

Artificial neural networks are one of the most popular methods used to predict future data whether it involves energy, the stock market, economics, crisis and others. There are two methods in artificial neural networks which are multilayer perceptron and radial basis function, but in this analysis, multilayer perceptron (MLP) was selected. The multilayer perceptron is a network consists of a number of highly interconnected simple computing units called neurons or nodes which are organized in layers. Multilayer networks are more powerful than single-layer networks because, in multilayer networks, each neuron performs a simple task of information processing by converting received inputs into processed outputs. Through the linking arcs among these neurons, knowledge can be generated and stored as arc weights regarding the strength of the relationship between different nodes. Although each neuron implements its function slowly and imperfectly, collectively a neural network can perform a variety of tasks efficiently and achieve remarkable results.

In this study, a three-layer feed-forward neural network is used where the three layers are consists of input, hidden and an output layer. The process starts with the inputs, x_i that are combined to form a weighted sum of inputs and the weights, w_i of connecting links. Next, the transformation that converts the sum to an output need to be performed via a transfer function or some references called it as the activation function. In other words, the neuron performs the following operations:

$$O_n = f(\sum_i w_i x_i) \tag{2}$$

where O_n is the output from this particular neuron and f is the transfer function. The transfer function is a bounded non-decreasing function. Even though there are so many possible choices for transfer functions, only a few of the functions are commonly used in practice. These include the sigmoid/logistic function, the hyperbolic tangent function, the sine, and cosine function and the linear/identity function.

SPSS software is used to run the analysis on energy prediction. Under the analyze menu, there are two options for neural networks which are radial basis function and multilayer perceptron. By using SPSS software, the number of hidden layers will be chosen manually compared to radial basis function. There are a few fundamental processes to train a neural network. First, the network is fed with training examples (which consist of a set of input patterns and desired outputs). Next, the input values are weighted and summed at each hidden layer node, and the weighted sum is then transmitted by the log-sigmoid function into the hidden node's output value, which becomes the input to the output layer nodes for each training pattern. After that, the network output values are computed and compared to the target values to determine how closely the actual network outputs match the desired outputs. Finally, the weights of the connection are changed so that the network can produce a better approximation to the desired output. This process is typically repeated many times until the differences between network output values and the known target values for all training patterns are as small as possible. The goal of this training is to find the set of weights that minimize the objective function. Thus, network training is an unconstrained nonlinear optimization problem. Numerical methods are usually needed to solve nonlinear optimization problems.

The most popular training method is the error back-propagation (BP) algorithm which is essentially a gradient steepest method (Rumelhart et al., 1986). The idea of the steepest descent method is to find the best direction in the multi-dimensional error space to move or change the weights so that the objective function is reduced most. This requires partial derivation of the objective function concerning each weight to be computed because the partial derivation represents the rate of change of the objective function. The weight updating, therefore, follows the following rule

$$w_{ij}^{new} = w_{ij}^{old} + \frac{\partial E}{\partial w_{ij}} \qquad \frac{\partial E}{\partial w_{ij}} = -\eta \frac{\partial E}{\partial z_i} \frac{\partial z_i}{\partial y_k} \frac{\partial y_k}{\partial w_{ij}} \tag{3}$$

where η is the learning rate which controls the size of the gradient descent step.

Learning rate can be susceptible in choosing the right value. Theoretically, too small learning rate would lengthen the estimation time while too large learning rate may cause network oscillation in the weight space. The momentum parameter is added to modify the basic backpropagation so that the oscillation in weight changes and a weight decay term that penalises the overly complicated network with large weights can be controlled. In this study, these values are fixed where learning rate and momentum are set to 0.3. The combination of low learning rate and momentum rate gives much lower mean prediction error than a high learning rate of 0.6 and momentum rate of 0.6 (Abd Hamid, Anak Richard and Ramli, 2017).

Linear Regression

Linear regression method is selected as a comparison with the proposed method in this analysis because it is the most common method used by industries in this country. In this analysis, a scatter plot created by using Microsoft Excel and the data taken is the energy consumption (kWh) and outside temperature (°C). The regression line is created to describe the relationship between independent and dependent variable where in this case is outside temperature and energy consumption respectively. The year 2013 is taken as a baseline, and the linear equation that was obtained is used to predict the energy consumption for the next month.

Energy Efficiency in Commercial Buildings

Energy efficiency is a process towards reducing the energy consumption in any area or facility without affecting the comfort level of end user. After an energy audit, there are 9 recommendations for the Skywarth building and 7 recommendations for the Skymage building for further improvement in term of energy consumption. From energy analysis, the most facility that consumes higher electricity in the commercial building excluding chilled water is the lighting and the air handling unit. Based on the energy audit energy cost saving measurement (ESMs), there are several potential areas had been identified to reduce the energy consumption without affecting the end user's comfort. The energy cost saving measurement (ESMs) in this research is specific to reduce the energy consumed by the highest energy contributor which is the lighting system. The classification of the energy efficiency approach is shown in Table 4 below:

Table 4: Energy efficiency approach classification

1 No / Low Cost Easy	3 Medium Cost / High Cost Easy
2 No / Low Cost Hard	4 Medium Cost / High Cost Hard

Potential energy efficiency approach in Skywarth

A total of 9 Energy Cost Saving Measures (ESMs) were identified, as listed in Table 5 and the ESMs are divided into three categories as shown below:

Table 5: Energy cost saving measurement for Skywarth building

1	Tariff Management: Apply for "Off Peak Tariff Rider"	Low cost Tariff Management
2	Control the Maximum Demand - Implement Maximum Demand Control Strategy (Manual Control)	No cost Tariff Management
3	De-lamp in a selected area	No Cost
4	Retrofit Normal Fluorescent Tube (36 W), Compact Fluorescent Downlight (18 & 26 W) and 50-W Halogen with equivalent LED.	Medium - High Cost
5	Reschedule operation hour for lighting	No Cost
6	Install Occupancy Sensors turn off approximately 50% of lamps when the area is not occupied.	Medium - High Cost
7	Run Energy Awareness Program to ensure all Office Equipment and Lighting are turned off by end users.	Low Cost
8	Create 24 hours Mobile Workstation to reduce lighting & cooling energy required to run equipment after hours	No Cost

Potential energy efficiency approach in Skymage

A total of 8 Energy Cost Saving Measures (ESMs) were identified at the Skywarth which listed in Table 6 below:

Table 6: Energy cost saving measurement for Skymage building

1	Tariff Management: Apply for "Off Peak Tariff Rider"	Tariff Management
2	Control the Maximum Demand - Implement Maximum Demand Control Strategy (Manual Control)	Tariff Management
3	De-lamp in a selected area	No Cost

4	Retrofit Normal Fluorescent Tube (36 W), Compact Fluorescent Downlight (18 & 26 W) and 50-W Halogen with equivalent LED.	Medium - High Cost
5	Reschedule operation hour for lighting	No Cost
6	Install Occupancy Sensors turn off approximately 50% of lamps when the area is not occupied.	Medium - High Cost
7	Run Energy Awareness Program to ensure all Office Equipment and Lighting are turned off by end users.	Low Cost
8	Create 24 hours Mobile Workstation to reduce lighting & cooling energy required to run equipment after hours	No Cost

RESULTS AND DISCUSSION

The results from this analysis are separated into two parts; the prediction of energy consumption by using three different mathematical methods and the building energy index calculation. After implementing energy efficiency approach, energy prediction results can be used to determine how much saving could be obtained. The primary method in this analysis is ARIMA while the other two methods are used for comparison only. The input used for energy prediction is outside temperature since that the only available data although the correlation results with energy consumption are weak which 0.14. The results of energy prediction are shown in figure 3 and figure 4 below for Skywarth and Skymage building respectively:

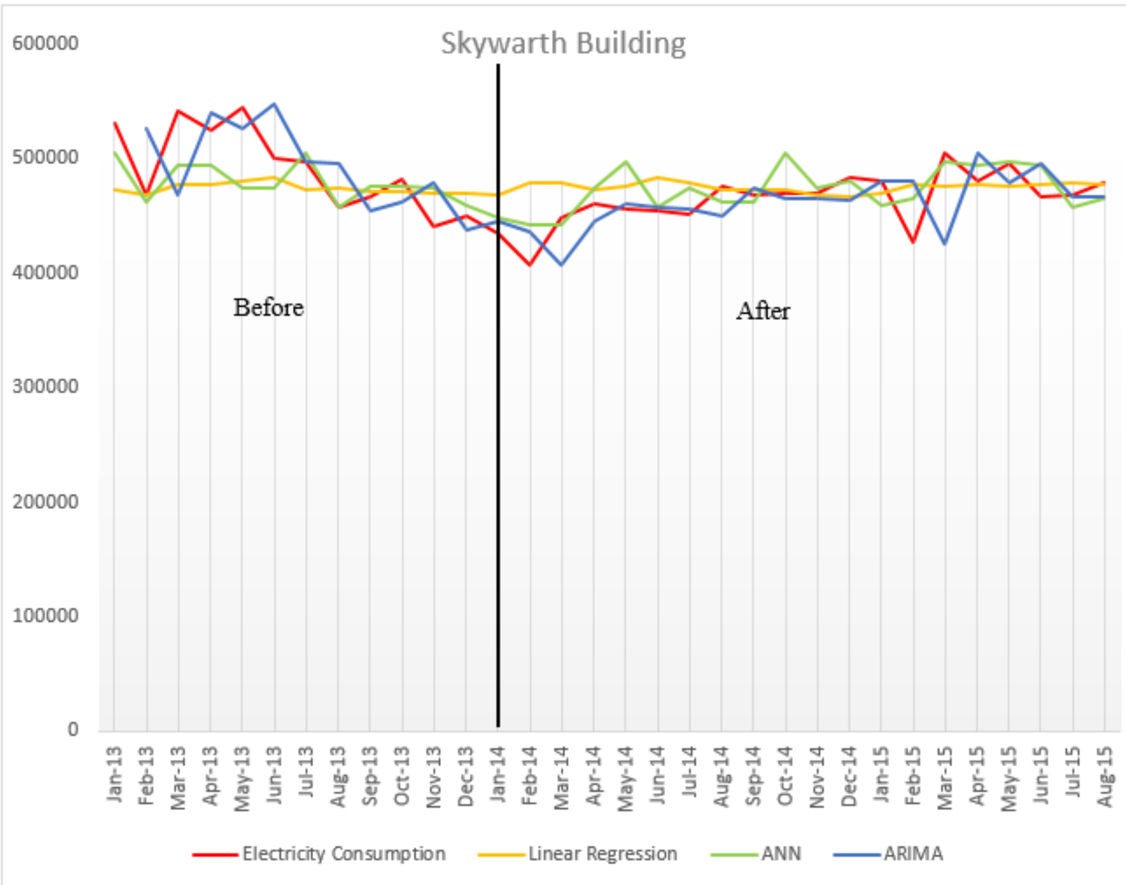

Figure 3: Energy prediction between ARIMA, ANN and linear regression for Skywarth building

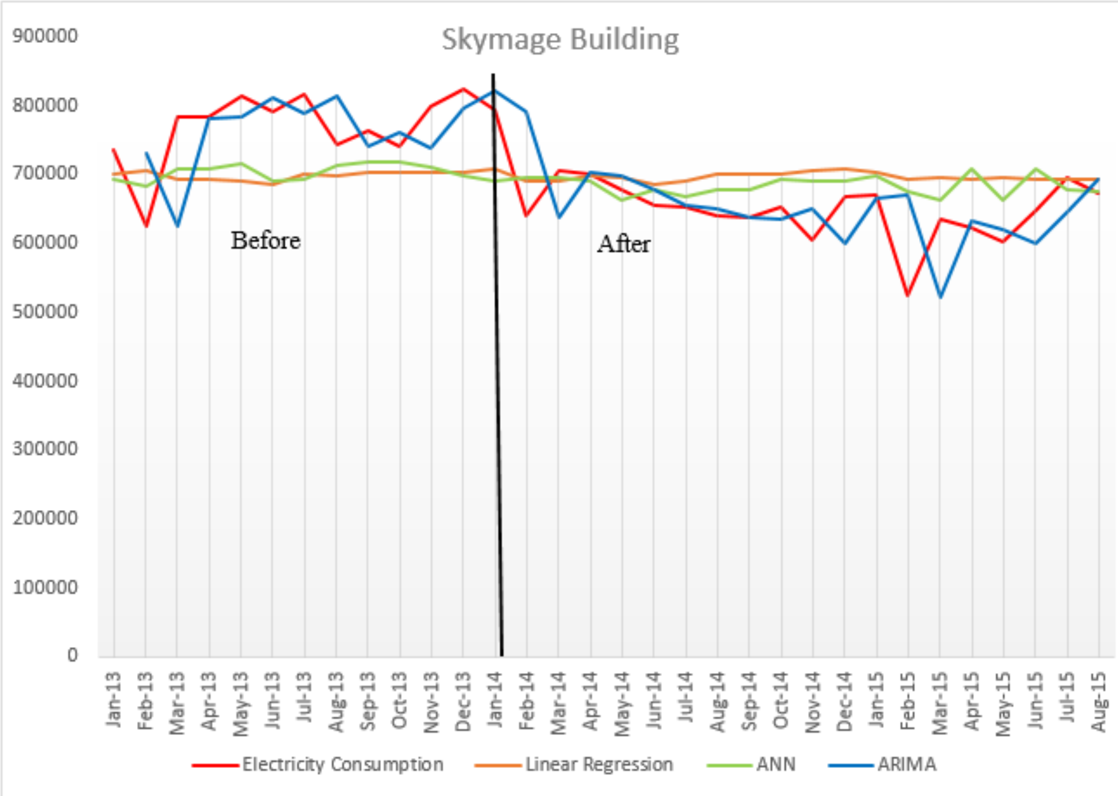

Figure 4: Energy prediction between ARIMA, ANN and linear regression for Skymage building

Based on the prediction of these three methods, this research provides the baseline for the Skywarth and Skymage building. The purpose of the baseline is to develop the Building Energy Index (BEI) for each of the building. Building Energy Index is a representation of the annual energy consumption per meter square of a facility. The BEI is used to compare energy consumption relative to similar building types or to track down the energy consumption from year to year in the same building. The BEI can be reduced by applying the energy efficiency approach that had been selected in this research which is retrofitting method. Retrofitting is an approach that applied to the building lighting system, where the typical fluorescent tube with 36W, compact fluorescent downlight with 18W and 26W and 50W halogen is changed to the equivalent LED product. The baseline was selected starting from January 2013 until December 2013. The amount of saving based on these three methods are shown in Table 7 below;

Table 7: Total cost saving between three different methods

Method	Total Cost Saving
Skywarth Building	
ARIMA	RM 172,114.30
Artificial Neural Network	RM 55,639.15
Linear Regression	RM 82,553.30
Skymage Building	
ARIMA	RM 309,547.40
Artificial Neural Network	RM 147,639.60
Linear Regression	RM 113,876.32

From Table 7, the highest saving that can be obtained for the Skywarth building is by using ARIMA where the amount of cost that can be saved is worth RM172,114.30. The similar results are obtained for the Skymage building, and the amount that can be saved is RM309,547.40. In this research, the energy efficiency approach that been considered is the retrofitting of the lighting system.

The Same approach is applied to both buildings to improve the energy consumption and the total cost to implement this method is worth RM499, 539.00 for each building. The value of investment for both buildings is considered the same as both buildings are not fully occupied based on the building net usable area. Table 8 and Table 9 below show the Building Energy Index based on the baseline, the Building Energy Index based on the baseline prediction by using the artificial neural network, potential energy saving based on the energy efficiency approach and the return of investment:

Table 8: Building Energy Index for Skywarth Building

Annual Electricity Consumption (Actual) (kWh)	**5,907,068.00**
Building GFA (exclude basement) (m²)	50,064.00
Building Nett Usable areas (m²)	38,187.00
BEI based on GFA (kWh/m²/year)	118.00
BEI based on Nett Usable/Lettable Areas (kWh/m²/year)	155.00
Annual Electricity Consumption (ARIMA)(kWh)	**5,435,522.00**
BEI based on GFA (kWh/m²/year)	108.60
BEI based on Nett Usable/Lettable Areas (kWh/m²/year)	142.34
Potential Saving (RM)	172,114.30
Energy Efficiency Retrofitting Approach Investment (RM)	499,539.00
Return of Investment, ROI (Years)	**3 Years**

Table 9: Building Energy Index for Skymage Building

Annual Electricity Consumption (Actual) (kWh)	**9,219,390.00**
Building GFA (exclude basement) (m²)	71,598.00
Building Nett Usable areas (m²)	54,005.00
BEI based on GFA (kWh/m²/year)	129.00
BEI based on Nett Usable/Lettable Areas (kWh/m²/year)	171.00
Annual Electricity Consumption (ARIMA)(kWh)	**8,371,315.00**
BEI based on GFA (kWh/m²/year)	116.92
BEI based on Nett Usable/Lettable Areas (kWh/m²/year)	155.00
Potential Saving (RM)	309,547.40
Energy Efficiency Retrofitting Approach Investment (RM)	499,539.00
Return of Investment (Years)	**2 Years**

CONCLUSIONS

Electricity cost keeps on rising every year. To reduce electricity cost, energy efficiency measures need to be implemented. In this research, energy efficiency measures had been done through energy prediction where the results showed that ARIMA is the most accurate method compared to linear regression and artificial neural network. This study also determined the energy accounting to identify the highest energy consumption contribution from equipment or system in the commercial buildings. From the energy analysis, some potentials of energy efficiency approach were identified for both Skywarth and Skymage buildings. Finally, from the analysis that had been conducted, some guidelines can be proposed to the industry to improve the energy consumption and cost saving. The guidelines are; first, energy audit needs to be conducted to identify the factors that affect the energy consumption in the building. The next step is to identify the potential of the energy efficiency approaches that can be conducted in a building. Based on the previous bill, a baseline can be developed to determine the amount of saving through the potential energy efficiency approach. Then, come out with the cost for the implementation of the energy efficiency approach that had been selected based on the amount that each building owner intends to invest starting from the low-cost part. Based on this guideline, the energy efficiency can be conducted with more proper methods compared to the existing approach by the industry. For future study, another factor should be included as an independent variable to predict energy consumption as one factor might not be enough to obtain accurate results.

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