Monitoring and Analysis of Energy Consumption on Jabatan Kastam Diraja Putrajaya's Building

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Abstract— **The objective of this research is to study the process involved in energy audit and analyze the energy consumption i.e. electricity and chilled water of a gas district cooling (GDC) plant at Pejabat Kastam Diraja Kompleks Kementerian Kewangan Putrajaya. In addition, it is also to conduct a cost benefit analysis and cost saving based on data collected. Energy audit is well-known in developed countries and it is a kind of inspection, survey and analysis of energy flows for energy conservation in a building, process or system to reduce the amount of energy input into the system without negative affecting the output [1]. However, this study is only cover the electrical aspect in the energy assessment. The data is collected from the building control system (BCS) and the trend of the energy consumptions are analyzed using Microsoft Excel. From the trend, possible energy saving is identified.**

Keywords-component; energy audit; gas district cooling (GDC); building control system (BCS); microsoft excel;

I. INTRODUCTION

The world is now facing many serious major problems concerning electrical energy sources such as lack of non-renewable energy source, inappropriate renewable energy use and energy generating process causing horrible side effects. Therefore, people and government must concern about energy efficiency, energy consumption and energy management in buildings. These factors are very important to minimize the energy costs, minimizing waste and minimizing environmental degradation. Energy audit is considered as one of the comprehensive methods in checking the energy usage and wastage in buildings [2]. Countries like United States and Australia are quite advance in this energy assessment. On the other hand, Malaysia is still in the early stage of its implementation.

The Energy Audit is the key to a systematic approach for decision-making in the area of energy management. It attempts to balance the total energy inputs with their use, and serves to identify all the energy streams in a facility. It quantifies energy usage according to its discrete functions. Energy audit is an effective tool in defining and pursuing a comprehensive energy management program within a business. Energy audit also defined as a verification, monitoring and analysis of use of energy including submission of technical reports containing recommendations for improving energy efficiency with cost benefit analysis and an action plan to reduce energy consumption [3].

Energy efficiency is very important in order to respond to rising energy prices and concern for the environment [4]. Presenting large energy amounts of consumption by the building force the government to make a better decision in energy management. Energy audit is able to organize the energy use and cost, diagnostic monitoring of buildings, support external reporting, and creating an energy reduction strategy for the future.

In this project, an assessment on how energy is consumed at Pejabat Kastam Diraja Komplex Kementerian Kewangan Putrajaya has been analysed. The objectives of this study is 1) to study the process involve in energy audit, 2) analyses energy consumption at Pejabat Kastam Diraja, Komplex Kementerian Kewangan Putrajaya, 3) to perform cost saving analysis from the trend of the energy consumption, 4) to propose some methods to reduce energy consumption in the building.

II. BUILDING PROFILE OF PEJABAT KASTAM DIRAJA KOMPLEK KEMENTERIAN KEWANGAN PUTRAJAYA

Jabatan Kastam Diraja Putrajaya consists of two building which is 2G1A and 2G1B. 2G1B building with two separate blocks where the first block has ten-storey and the second block has nine-storey located side by side. On the other hand 2G1A office is an eight-storey with three separate zones. The gross building floor area for both 2G1B and 2G1A building is 74,585 square meters. These are shown in Table 1. The nature of operation is an office administration which is operated mostly during working hours of 8 hours/days, 22 days/month from 7.00 am to 7.00pm daily.

The energy audit process has been carried out for the following active systems at each of the building which is BCS, air conditioning system, building lighting system, ventilation system/indoor air quality and office equipment. The detailed and operating scheduled of most active equipment for this building area are shown at the Table 2.

Based on the TNB website, the detail of billing structure for 2G1 buildings from TNB before and after June 2011 is shown on the Table 3 [5].

Table 1: Building details

Blok		No. of person	No of storey	Rough estimated floor area(m^2)
2G1B	Utara	1119	10 floors	24,159.35
	Selatan		9 floors	27,309.85
2G1A	Zon 1	527	8 floors	3,646.32
	Zon 2		8 floors	7,404.94
	Zon 3		8 floors	12,092.10

Table 2: Schedule of building system

Building System	Description	Schedule	Hours
Lighting	Office area	6.00am-6.00pm	12
	Common area (core)	24 hours	24
	Façade light	7.00pm-12.00pm	5
	Landscape light	7.00am-7.00pm	12
Air conditioning	Air handling units (AHU)	6.00am/7.00am – 7.00pm	12
	Fan coil units (FCU)	24 hours	24
	Chilled water pump (primary)	7.00am-7.00pm	12
	Chilled water pump (small)	7.00pm-7.00am	12
	Precission airconditioning (datacenter)	24 hours	24
Ventilation	Fresh air fan, smoke exhaust fan, toilet exhaust fan	7.00am-7.00pm	12

Table 3: Electrical tariff

	Before June 2011	After June 2011
Tariff structure	Commercial C1 tariff	
Consumption kWh charges	RM 0.288/kWh	RM 0.312/kWh
Maximum demand value and charges	RM 23.930/kW	RM 25.90/kW
Voltage level	415V	415V
Power factor	>0.85 to 1	>0.85 to 1

III. METHODOLOGY

The methodology of this project consist of four steps such Literature Review and Initial Preparation, Understanding about Management and Energy Audit, Energy Audit Steps and Documentation as shown in figure 1.

A Literature Review and Initial Preparation

Information related to this project are searched. Journals, Text book, IEEE website, Google and wikipedia are the main references. The building profile, objectives, the definition, the policy, the factors, the principles, the feasibility, and the procedure of energy management and energy audit are studied.

B Understanding about Management and Energy Audit

Energy audit is defined as the verification, monitoring and analysis of use of energy including submission of technical report containing recommendations for improving energy efficiency with cost benefit analysis and an action plan to reduce energy consumption. Energy management is define as the judicious and effective use of energy to maximize profits (minimize the cost) and enhance competitive positions.

C Energy Audit Steps

On the first stage of energy audit, all the basic information collected include the monthly electric bills, electric tariff, floor plans, list of equipment, technical specification of major equipment, and operating schedules of equipment [6].

On the second stage, the reading for fixed or portables collected from BCS and also from manually measuring instrument. When all data are completely recorded, the quantity energy consumption on major equipment of energy mapping can be obtained for electrical and GDC side. Qualitative assessment on the building and its systems. The data are taken from January 2010 until June 2012.

On the third stage, evaluation of improvement measure which is the suitable measurement are determined to improve energy efficiency and for conversion.

D Documentation

Documentation is a process of documenting knowledge and writing of project documentation. Documentation may include written information for any read, projection or technical performing, data media of any format and any reproduction other content.

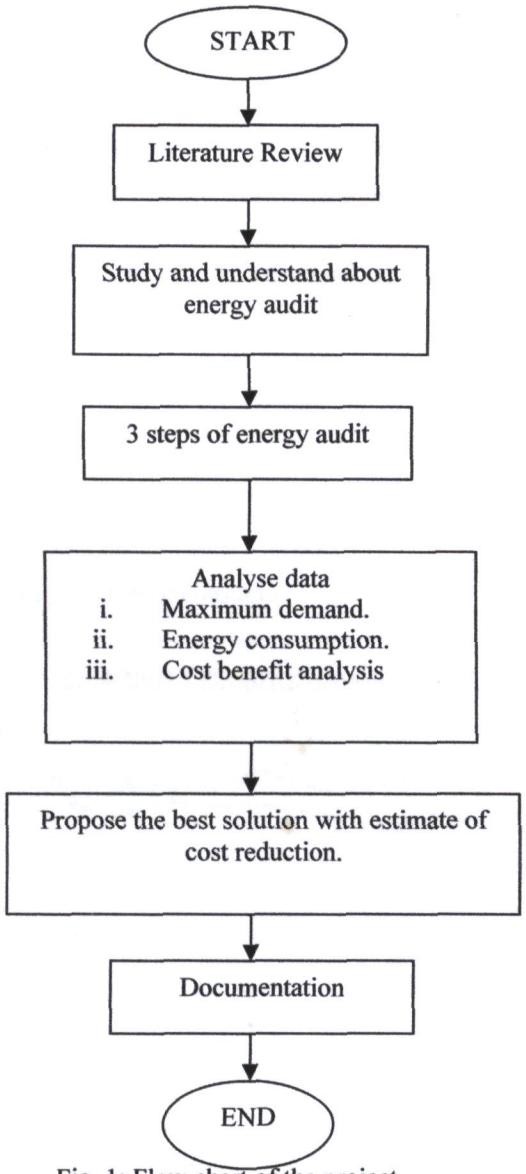

Fig. 1: Flow chart of the project

IV. RESULT AND DISCUSSION

A. Energy consumption Review

i. Monthly Profile

The data of Blok 2G1 Jabatan Kastam Diraja Putrajaya for January 2010 until Jun 2012 were collected from BCS includes electrical consumption, electrical demand, energy variable changes, and demand charges.

The monthly load profile was established from 1/01/2010 to 30/07/2012 and is shown in Fig. 2. During this period, the average monthly consumption of electricity amounted to 844,285.25 kWh (year 2010), 818,345 kWh (year 2011) and 782,771.33 kWh (year 2012). The average consumption and Fig. 2 show that there is some improvement in the electricity consumption which is reducing every year, caused by the energy audit that has been conducted annually. Other than that, the decrease in the electricity consumption is also caused by worker awareness and the replacement of high power bulbs to the low power bulbs. In February of each year, the energy consumption appears to be the lowest compared to January and March because of the working days are lower than those months. For example, in 2011 and 2012, Chinese New Year is happen in February and 1st February every year is a Federal Territory for Putrajaya. The trend of the graph as in Fig. 2 decreases from January to February of each year.

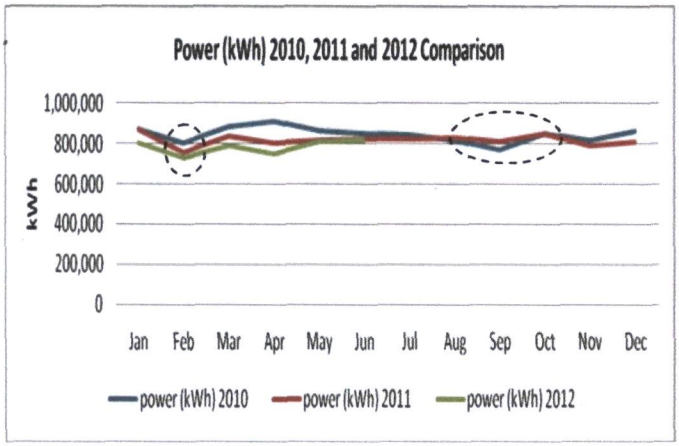

Fig. 2: Electricity consumption per month

The pattern of graph in Fig. 2 shows that the electricity consumption is decrease but the pattern of graph in Fig. 3 is different which shows that the cost of electricity consumption is increase. The different pattern of these graphs is occur caused by the increasing Medium Voltage General Commercial tariff from 28.8 cents per kWh to 31.2 cents per kWh after May 2011. Tenaga Nasional Berhad (TNB) has announced that the natural gas price to the power sector will be increased from 1st June 2011. As a result of the gas price increase, TNB's gas bill will increase by about RM1.5 billion per year. Due to the gas price increase, TNB will have to increase the electricity tariff to cover for the additional cost. The increase in natural gas price is based on the Government natural gas pricing mechanism in which the price is reviewed every six months in tandem with the market price trend [5].

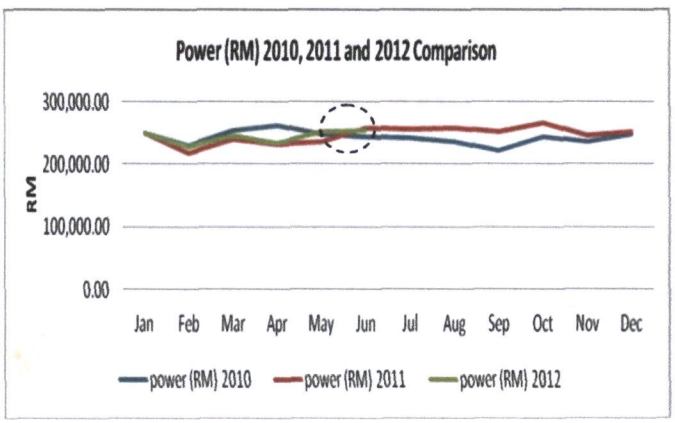

Fig. 3: Cost of electricity consumption per month

Fig. 4 shows the comparison of overall power consumption kWh which is the sum of electrical consumption and GDC chilled water total usage among years 2010, 2011 and 2012. The pattern of graph in Fig. 4 is almost same with graph in Fig. 1.

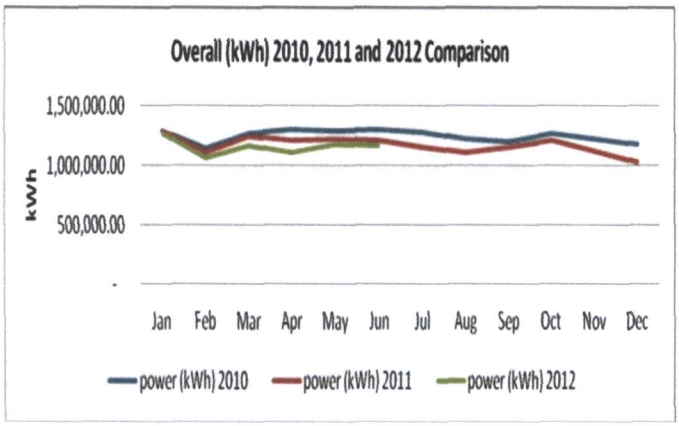

Fig. 4: Overall consumption per month

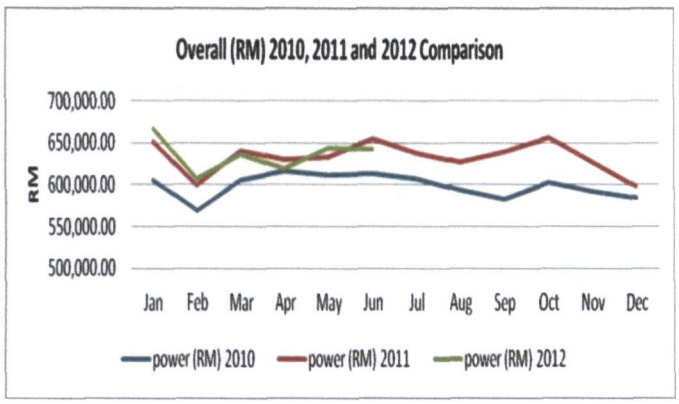

Fig. 5: Overall cost of consumption per month

The overall cost of power consumption for Jabatan Kastam Diraja Putrajaya from 1st January 2010 until 30th June 2012 is RM 18,596,720.18. The average cost of power consumption for year 2010, 2011 and 2012 are RM 598,713.94 , RM 633,015.38 and RM 635,994.43 . These values show that the cost of power consumption of this building is increasing every year and this is not good for government. The increasing of tariff for both electricity and GDC chilled water is the main cause of the increasing overall cost of consumption even though the overall consumption is decreases. The electrical consumption tariff is increase from 28.8cents to 31.2 cents per kWh and the electrical demand tariff is increasing from RM23.93 to RM25.90 per kW. Both electrical tariffs are increase after May2011. The GDC chilled water tariff increasing after December 2010. The energy variable charges increasing from 22.8 cents to 24.8 cent per kWh and the demand charges is increasing from RM104.88 to RM114.33 per kW.

ii. Daily Profile

Based on Fig. 6, the electricity demand during working days in 2G1B building are higher than the electricity demand during weekends, where during working days the electricity demand raised slowly after 6.00 am because during that time the lighting at office area is started to turn on while the graph is raised drastically after 7.00 am because during that time all the ventilation system and lighting system which is in office area, common area, façade area and landscape area is starting to turn on. The electricity demand reaches the peak at 8.30 a.m. while during the lunch hour the electricity demand remains constant due to the habit of the workers not to turn off the electrical equipments used in the office. On weekends, the pattern of the graph remains constant below 300 kW due only lighting at common area is turning on. To save the energy, it is recommended that the electricity demand should be reduced 50% from the difference of weekday and weekend graph during the lunch hour and the out of operation hours. By following the ideal curve, it could save energy up to 224,843.52 kWh equals to RM 70,151.18 per year, subjected to 2012 TNB electricity tariff which is RM 0.312 per kWh.

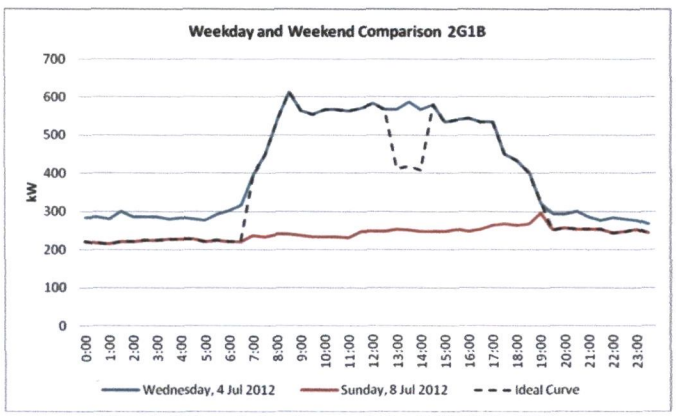

Fig. 6: Electricity demand for 2G1B building

The electricity demand for 2G1A during weekends increases during 7.00am because some of the offices operate seven days a week where due to overtime, the electricity demand remains high after 2.30 pm until 5.30pm. Generally the electricity demands during working hours on weekdays are higher than weekends because of more offices operate on those days. By following the ideal curve, it could save power consumption up to 70,057.68 kWh equals to RM 21,858 per year, subjected to 2012 TNB electricity tariff which is RM 0.312 per kWh. The power consumption saving obtained by following the ideal curve from building 2G1A and 2G1B combined is 294,901.2 kWh equals to RM 92,009.17 per year. Assume that the working days for a year is 264. There is a large amount of electric power consumption that can be saved where the less power used the more money could be saved.

Saving Calculation 1: If the load at 2G1B is kept at minimum and follow the ideal curve in Fig. 6 during out of operation hours on weekdays, average 50.8 kW and 242.06 kW of energy could be saved each hour between 7.00pm to 7.00am and 1.00pm to 2.00pm.

Table 4: Saving calculation 1

Operating Hour	Demand Saving kW	Hours	Consumption kWh	Working days per year	kWh/year	Cost saving Rm per year
7pm-7am	50.8	12	609.62	264	160939.7	50213.18
1pm-2pm	242.06	1	242.06	264	63903.84	19938.00
				Total	224843.5	70151.18

Saving Calculation 2: If the load at 2G1A is kept at minimum and follow the ideal curve in Fig. 7 during out of operation hours and lunch hour on weekdays, average 15.36 kW and 81.09 kW of energy could be saved each hour between 7.00pm to 7.00am and 1.00pm to 2.00pm.

Table 5: Saving calculation 2

Operating Hour	Demand Saving kW	Hours	Consumption kWh	Working days per year	kWh/year	Cost saving RM per year
7pm-7am	15.36	12	184.28	264	48649.92	15178.78
1pm-2pm	81.09	1	81.09	264	21407.76	6679.22
				Total	70057.68	21858.00

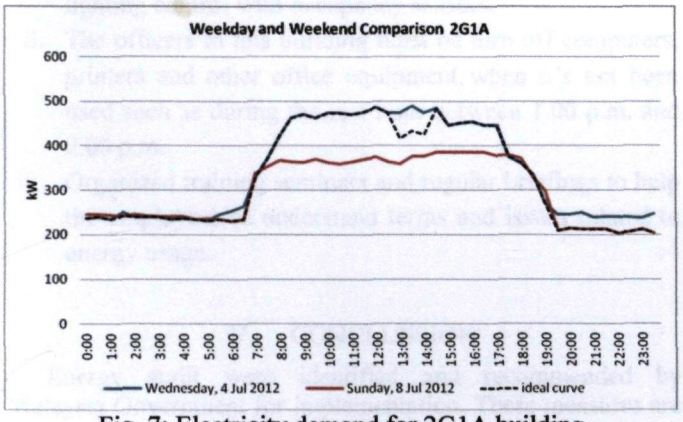

Fig. 7: Electricity demand for 2G1A building

The electrical demand of building 2G1A and 2G1B have been monitored every half an hour at the BCS for fourteen days from 3rd July 2012 until 16th July 2012 as shown at the Fig. 8 and Fig. 9. For the building 2G1B, the maximum electricity demand is recorded 619.4 kW at 4.30 p.m. Wednesday 11th July 2012 and the lowest electricity demand is 179.3 kW at 5.00 a.m. 7th July 2012. The difference between the maximum electricity demand and the lowest electricity demand for building 2G1B is 440.1 kW. While for the building 2G1A, the maximum electricity demand is recorded 495.04 kW at 4.30 p.m. Thursday 12th July 2012 and the lowest electricity demand is 193.12 kW at 12.00 a.m. 13th July 2012. The difference between the maximum electricity demand and the lowest electricity demand for building 2G1A is 301.92 kW.

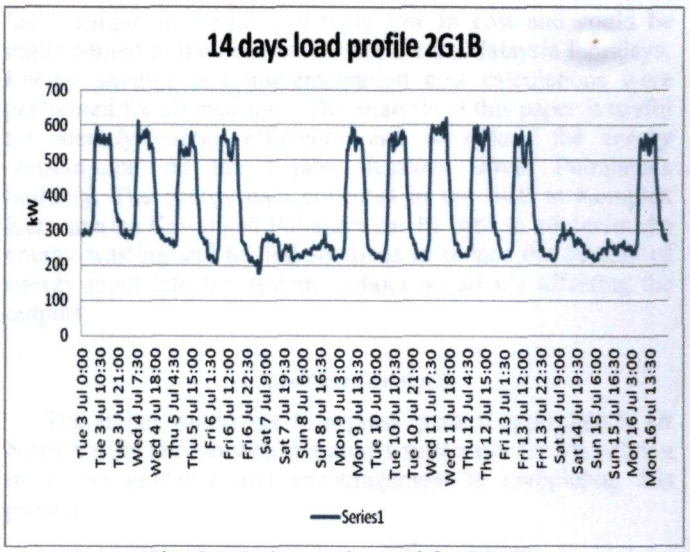

Fig. 8: Maximum demand for 2G1B

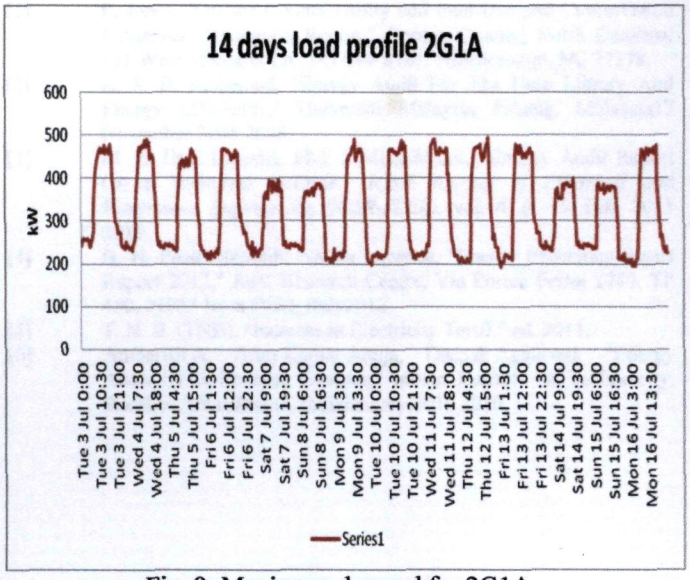

Fig. 9: Maximum demand for 2G1A

B Energy Apportion

Fig. 10 shows the total cost of energy consumption for the Pejabat Kastam Diraja's buildings. These consumption levels were derived by the combination of electricity consumption, electricity maximum demand, GDC chilled water energy variable charges and GDC chilled water demand charges. Based on this load profile, the following split in power consumption use has been established. The largest consumption is represented by electricity consumption which is made up of lighting system, ventilation system, computers, screen, printers, lift, and others electric devices cover 38% follow up by GDC chilled water demand covers 38%, GDC variable charges covers 17% and lastly electricity maximum demand covers only 7% from the overall consumption.

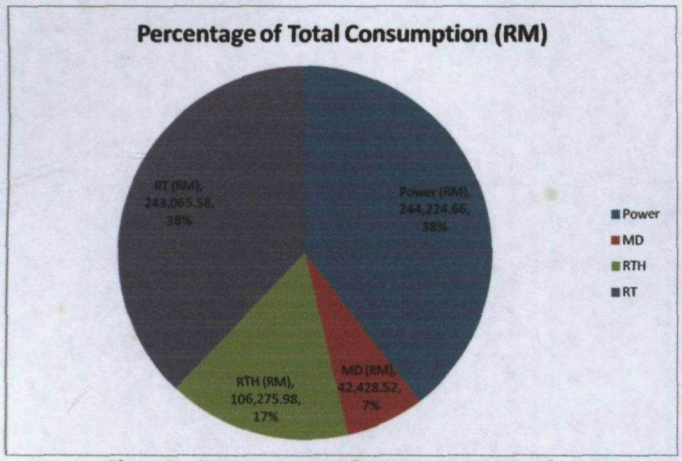

Fig. 10: Components of energy consumption

C. Saving Recommendation

Based on Fig. 10, possibilities to reduce the major largest energy consumption in the Jabatan Kastam Diraja were suggested as follows:

i. Install more efficient luminaries and install automatic lighting control with occupancy sensors.
ii. The officers in this building must be turn off computers, printers and other office equipment when it's not been used such as during the rest hour between 1.00 p.m. and 2.00 p.m.
iii. Organized training seminars and regular briefings to help the employees to understand terms and issues related to energy usage.

V. CONCLUSSION

Energy audit were identified and recommended by Malaysia Government for implementation. These measures are fairly simple in nature, relatively low in cost and could be implemented in the Pejabat Kastam Diraja Malaysia Putrajaya. Energy savings and implementation cost calculations were performed for all measures. The analysis in this paper is useful for identify energy efficiency and to reduce the energy consumption on the Pejabat Kastam Diraja Putrajaya's building. The energy data collected in the BCS at Komplex Kementerian Kewangan Putrajaya can be used to minimum the energy wasting and to find solutions to reduce the amount of energy input into the system without negatively affecting the outputs.

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