REDUCTION OF ENERGY CONSUMPTION BY ENERGY AUDIT AND ENERGY MANAGEMENT

By

SITI FATIMAH BINTI CHE AB MALIK

FINAL PROJECT REPORT

Submitted to the Electrical & Electronics Engineering Programme
in Partial Fulfillment of the Requirements
for the Degree
Bachelor of Engineering (Hons)
(Electrical & Electronics Engineering)

Universiti Teknologi Petronas
Bandar Seri Iskandar
31750 Tronoh
Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

REDUCTION OF ENERGY CONSUMPTION BY ENERGY AUDIT AND ENERGY MANAGEMENT

by

Siti Fatimah Binti Che Ab Malik

A project dissertation submitted to the
Electrical & Electronics Engineering Programme
Universiti Teknologi PETRONAS
in partial fulfilment of the requirement for the
Bachelor of Engineering (Hons)
(Electrical & Electronics Engineering)

Approved:

____

Ir. Dr Perumal
Project Supervisor

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK

May 2014

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.

Siti Fatimah Binti Che Ab Malik

ABSTRACT

This report discusses on research regarding energy audit and energy management. In this project, the project studies on the energy consumption of a pharmaceutical factory in Selangor. This project is focused on proposing a method for energy audit and suitable suggestion for energy saving and management. In order to achieve this objective, this report first discusses the potential of energy audit and energy saving measure that can be implement on site. The factory aims to reduce 5% of the monthly consumption. A details analysis of the collected data was illustrated in tables and graphs. The data was collected using power analyzer at the incoming supply of the equipment. From the data, it show that for this factory operation, the most consumption area of electricity is on Air Handling Unit(AHU) and lighting. Retrofit measures is taken such as implementing of Variable Speed Drives(VSD) for AHU. The installation can save up to 40% of the energy usage of that specific unit with the payback period between 8 month to 18 months. Delamping is a good measure in order to reduce the energy consumption for lighting. Malaysian Standard-Code Of Practice On Energy Efficiency And Use Of Renewable Energy For Non-Residential Buildings, MS 1525: 2001 is referred for the luminance minimum value. The factory achieved 2% of reduction in total energy consumption monthly. As conclusion, energy audit is the start point of the energy management program that aims to increase the energy efficiency of a facility by recognizing any possibilities to cut down the energy usage.

ACKNOWLEDGEMENTS

First of all, deepest gratitude goes to Allah for providing me the opportunity to step in Universiti Teknologi Petronas and giving me strength in completing the studies and this final year project. Special thanks go to my helpful supervisor Ir. Dr. Perumal. His invaluable help of supervision, constant support and suggestion throughout the progress have contributed to the success of this final year project.

My sincere appreciation to Raman A/L Achutan for consultation, help, sharing the knowledge and opportunity for me while conducting this project. I will also like to thank my seniors, Nurul Syafiqah Najib for her guidance during the early stages of this project. A special appreciation goes to Mr.Mohd Zuraimi B Abd Rahman and Elnazer for their kind assistance and cooperation. All activities during the program would not be possible without the help and support from all of you.

Lastly, I will also like to thank my parents, family and friends for their continuous support and prayers.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter 1
INTRODUCTION

1.1 Background

Start entering text here. Since 1970 , Malaysia has undergone rapid development as multisector economy are introduced in order to fulfill the goal of becoming develeop nation by year 2020. This lead to increase in energy demand which include in electricity and production supply as analyzed by Malaysia Energy Information Hub (MEIH) in Figure 1. [1] Based on MEIH research, the oil produced in year 2011 is approximate to 140897.45 GWh. Up until 2020,the energy demand is predicted to keep rise up.

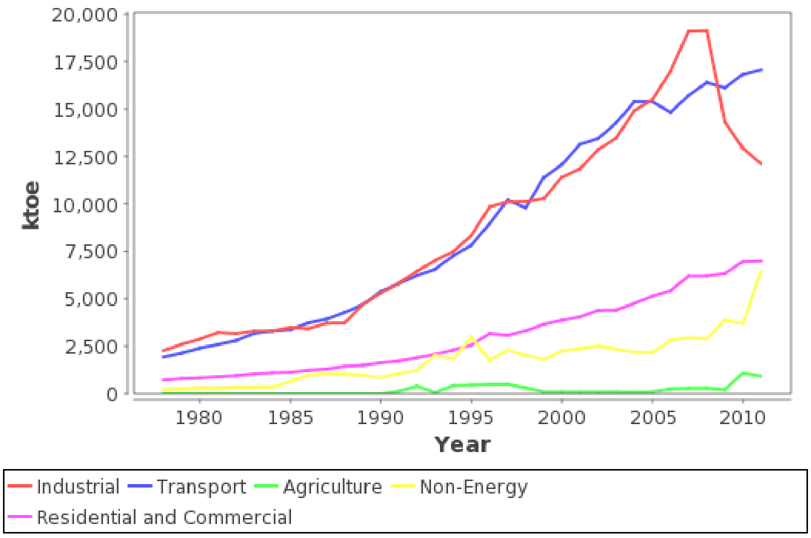


Figure 1 Graph of Electricity Demand and Generated from Various Sector [1]

The efficient use of electrical energy has been a major trust by the government to reduce the total electricity consumption of the county. This project is about finding ways of using electricity efficiency by means of energy audit and energy management.

1.1.1 Energy Efficiency

According to International Energy Agency, managing the growth in energy consumption or using less energy to provide the same service is defined as energy efficiency. To be competitive in industry, it is important to always have a continuous action plan and progression in energy efficiency. Not also the company can save in their energy bills by reducing cost of production, it also can lessen the cost for their energy infrastructure. This program definitely give a high impact to the environment as well as society.

1.1.2 Energy Audit

To find out what, how and when energy is consumed in a facility, the process of energy audit can be conducted. It is the start point of the energy management program that aims to increase the energy efficiency of a facility by recognizing any possibilities to cut down the energy usage. [3]

1.1.3 Energy Management

Energy management is a method of altering and optimizing energy by utilizing system and method with the objective of continually reducing energy consumption and maintaining the efficient energy.

1.2 Problem Statement

It is certain that oil and gas resources shall become depleted in the upcoming future.[4]Moreover, the the effect of greenhouse gas (GHG) emission has become a major security threat as it can causes negative impact on environment. The chairman of Shell Malaysia, Mohd Anuar Taib claimed that 60% of total world GHG emissions originated from fuel consumption which supports the argument stated. Figure 2 shows the trend of increasing carbon dioxide emission in Malaysia from year 2007 to 2011. The data is taken from U.S. Energy Information Agency website. [5] By 2020, Prime Minister of Malaysia agreed to reduce 40% of the carbon dioxide emission. That agreement was made during the United Nations Climate Change Conference in 2009. [6]

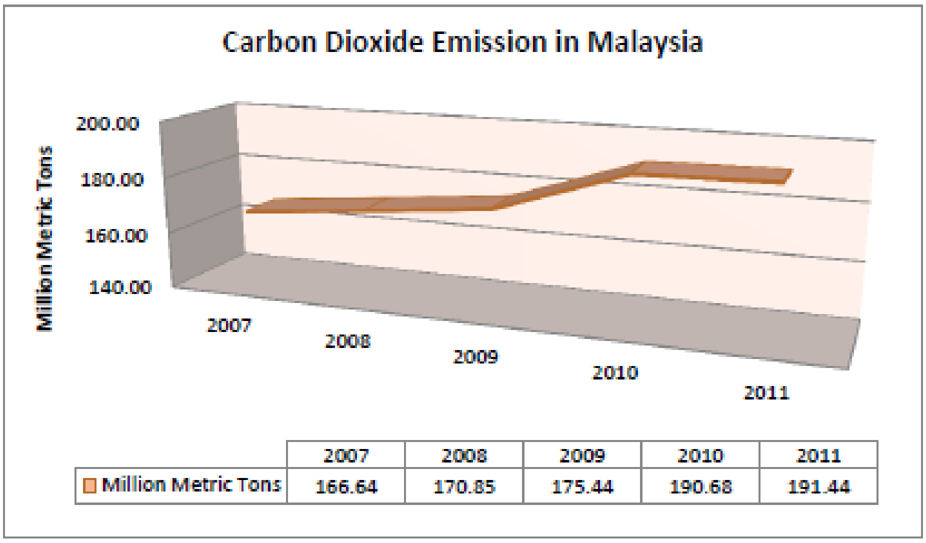


Figure 2: Increasing carbon dioxide emission in Malaysia from year 2007 to 2011

In Malaysia, *under "Electricity Supply Act 1990" there is a regulation that has been implemented and effective since 15th December, 2008 which is Efficient Management Of Electrical Energy Regulations 2008 (EMOEER 2008) that applies to any installations (buildings, factories, etc) who consume more than 3,000,000kWh over a period of 6 months. The regulation states that, any installation under that criteria should carry out energy audit, usage monitoring, efficiency programs and submit status reports to the "Energy Commission", Malaysia. [7]*

1.3 Objective and Scope of study

The main objective of this paper is divided into two . The divisions are as follows:

1. To collect data for Energy Audit at pharmaceutical factory(GlaxoSmith Kline) and analysed it by using the software; Power Vision and Power Studio.

2. To propose methods of improving energy consumption and managing them.

Chapter 2
LITERATURE REVIEW

2.1 Literature Review and/or Theory

According to Gomes, Coelho, and Valdez energy audit is the process to find out what, when and how energy is used in a specific area and it is the starting to increase the energy efficiency of building by find out any chances of saving in that area to reduce the energy consumption.[8] In other words, energy audit simply can be seen as the kick start of the development of electrical efficient measures (EEM). By conducting energy audit, energy saving measure can be identified and the organization can take immediate action to reduce the waste and at the same time increase the energy efficiency. [11]

There are four type of energy audit. The simplest is the walk-through, then an audit that analyses the utility cost together with the evaluation of metered energy uses and operating cost. Next is the standard energy audit and the most comprehensive audit is the detailed energy audit. [8] There are three steps for the process of auditing. First phase begin with preliminary analysis by considering the scope of audit. Next is walk-through energy audit for site survey and data collection. The last step is detail energy audit by analyzing the data collected.[12] Meanwhile, Australian/New Zealand 3598:2000 standard, classify the audit into 3 level; walk through assessment, energy survey and analysis and detailed energy audit. [9]

The methodology used for the energy audit in a school building in Pombal, Portugal , involved; building characteristics, analysis of the energy flow and possible energy saving. In the analysis of the energy flow section, the building energy use is identified based on the monthly electricity consumption data and power factor which were taken from the bill. Analysis for monthly consumption was made according to the changing of seasons and also school activities. Based electric load gained, they identified that lighting system is one of the main consumers. Analysis on the annual consumption of propane gas used also was carried out. Using power analyzer, data for energy load diagram was identified. The data at four different Partial Electrical Board was collected. The duration for the data collecting is a week for two different months. An analysis for the load diagram was made. [8] Most of the energy audit that carried out at public building show that, air conditioning system and lighting system are the main consumer of electricity. [9-12]

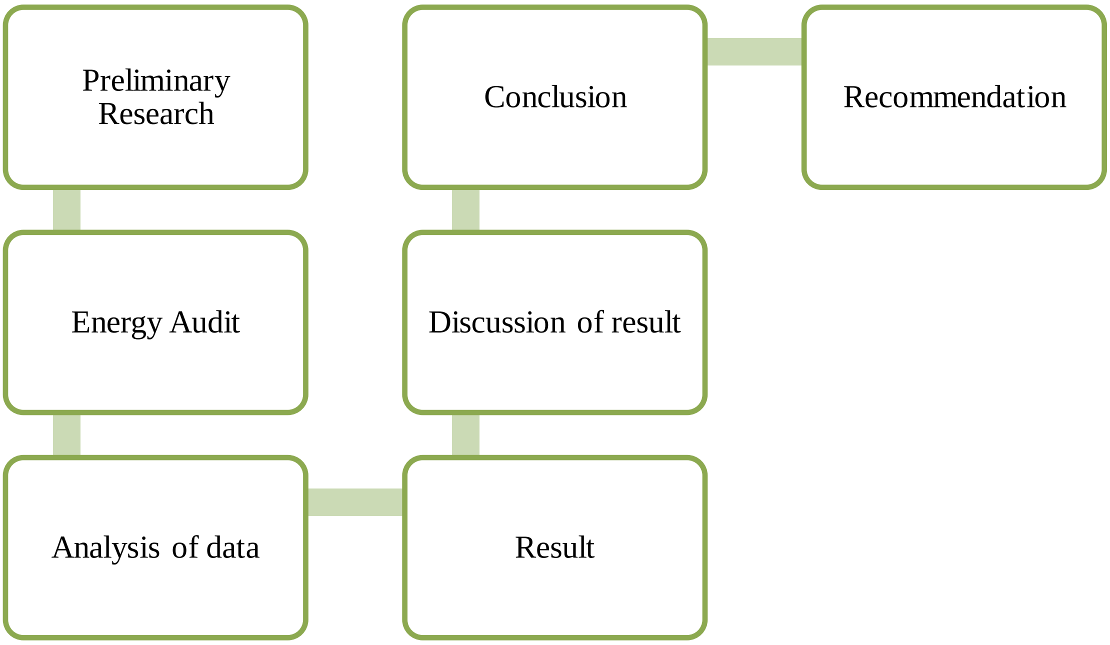
The audit at Universiti Teknologi MARA (UiTM) Penang compared their value with the Illuminating Engineering Society (IES) Recommended Practice Guides that provide the optimum luminance data to be used in different areas. For air conditioning system, the data compared with ASHRAE standard that state the value for energy efficient ratio(EER), specific power consumption(SPC) for the equipment. The level of lighting were measured by using the lux meter while for the air conditioning system, electrical energy, flow, pressure, and temperature meter were used to compare the real data with the data of efficient equipment efficiencies. [11]

At a commercial building in Shanghai, the audit was carried out on indoor environment which is to collect the data for indoor temperature, relative humidity(R.H) and CO2 concentration in winter. E+E automatic thermograph is used to test the indoor temperature and R.H. and auto tester is for CO2 concentration. . The reading is taken at 12 testing points in the specific area. This paper figure out that outer climate and office occupancy rate are two main factors that affect the energy consumption for air conditioning and other fields respectively. This paper also analyses the energy potential saving by thickening the glass curtain from 6mm to 8mm.[10]

Energy audit can also be carried out together with environmental audit. An audit at office building in Putrajaya which is Bangunan Kastam and Bangunan Menara Seri Wilayah aimed to investigate the performance of environmental and energy efficiency in two different buildings which have their own audit history. The data collected is analysed based on the standard measurement; which is Malaysian Standard 1525 (MS1525) for quality control of illuminance, temperature and relative humidity, while Department of Occupational Safety And Health, 2005 (DOSH 2005) is used as a quality control for carbon dioxide percentage in air. Different equipment is used for different purpose; Psensor RH for Co2 measurement, HT 305 for temperature and humidity measurement and Tento 540 for lumen measurement.[12]

Chapter 3
METHODOLOGY

3.1 Research Methodology



3.2 Project Activities

Preliminary Research	The information and data are collected from trusted sources such as IEEE web sites and books. By doing this, an expectation of methodology and result may be expected.
Energy Audit	The energy consumption of the year 2013 is collected and review. The target for reduction is set up. Collecting of data using Power Analyzer(Tool)
Analysis of Data	Using the Power Vision and Power Studio to analyse the data to get the energy profile.
Result	From the analysed data, the most consume area is identified.
Discussion of result	Further discussion will be made with the supervisor, or any related individual and from the preliminary research to come out with a solution or suggestion on energy management to reduce the energy consumption
Conclusion and recommendation	Conclusion will be made from the discussion. The recommendation is vital for future references. It is for the improvement and continuation in that field.

3.3 Gantt-chart and Key Milestone

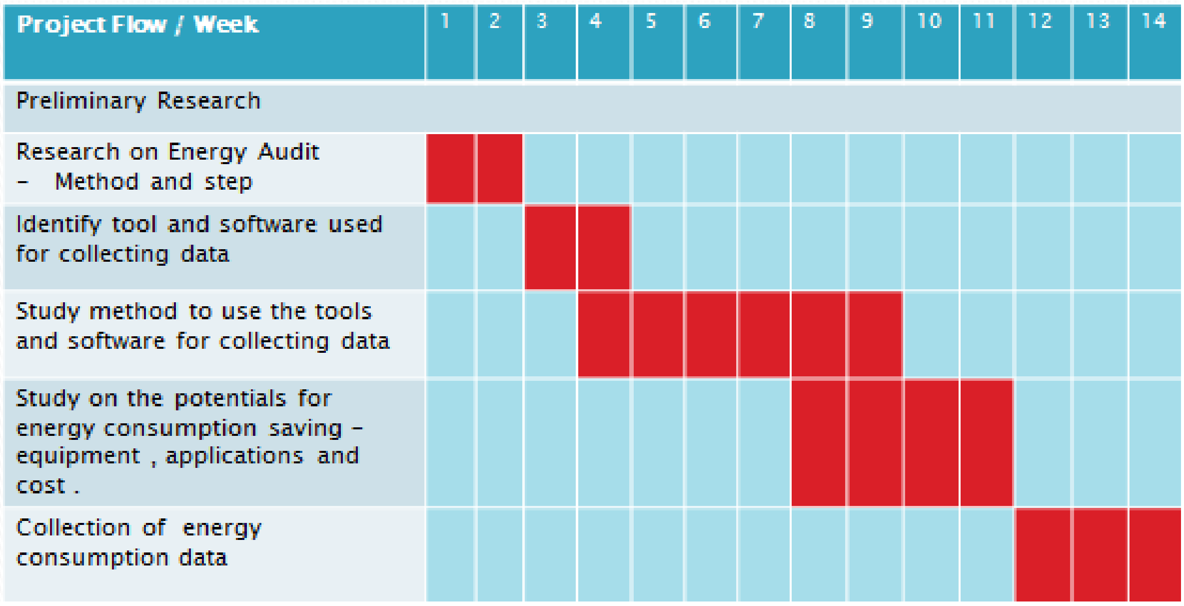


Table 1 Gantt-Chart for FYP

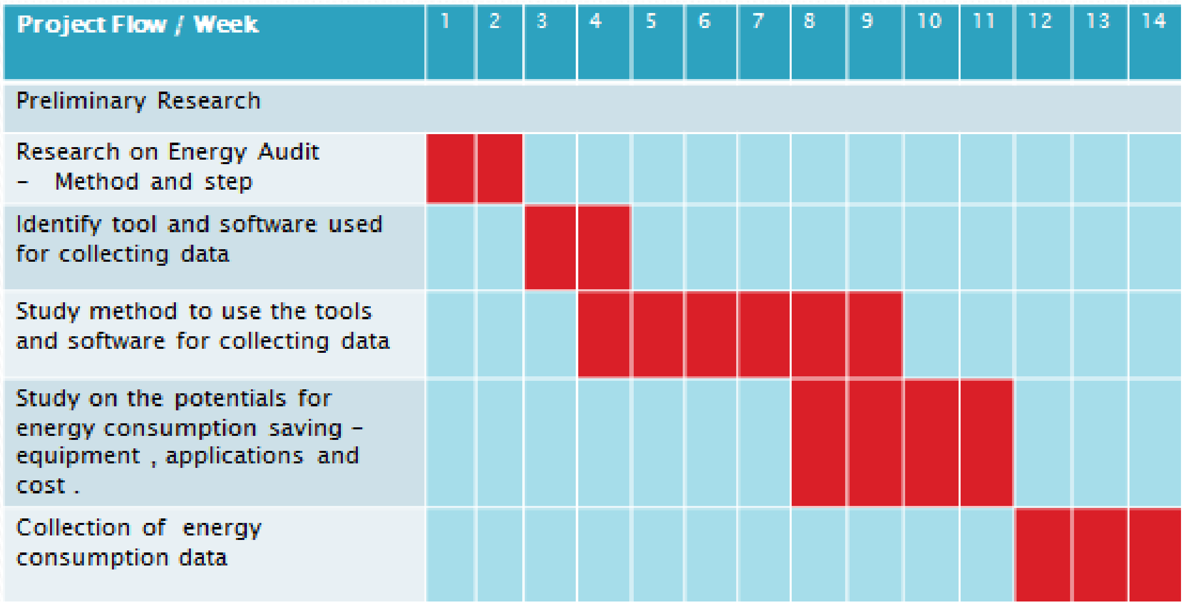


Table 2 Key milestone for FYP

Chapter 4
RESULT AND DISCUSSION

An energy audit was conducted in a factory in Ulu Klang. It is pharmaceutical factory that operate 24 hours, 6 days a week. It has been operating for more than 50 years. The major functional area of the energy usage and statistic is presented. The data below are important to understand the energy scenario of the factory. From here we can see the performance and potential saving for the factory. Data loggers and power analyzers are used to measure the energy consumption of the factory. Data have been collected using power analyzer at incoming electricity source of equipment. The aim of this collection is to identify different load patterns.

4.1 Factory Energy Sources and Consumption

The electricity for the factory is supplied through a grid connected power system from TNB. The data are collected to identify the contribution of the energy sources towards the factory's total energy requirement as shown in **Figure 3.**

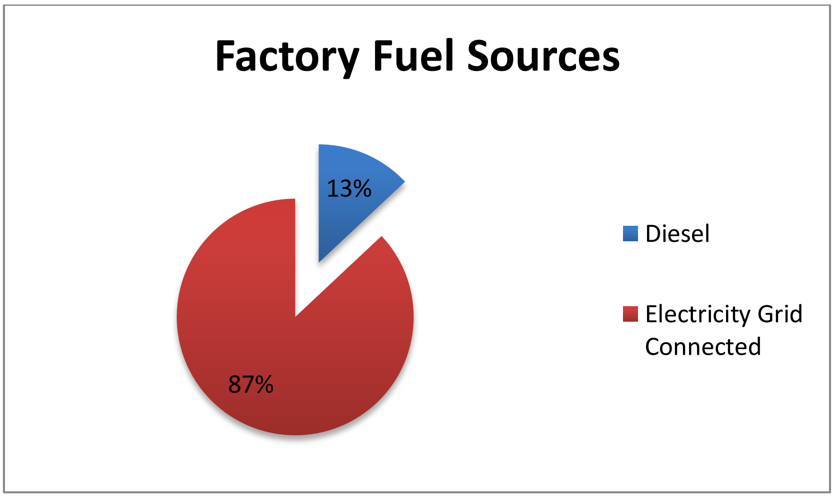


Figure 3 Factory Fuel Sources

Figure 4 presents the annual consumption of diesel in kg. The value is based on the bill. It can be seen ,87% which is majority of the factory fuel is coming from electricity from the grid and only 13% from diesel. The plant uses diesel fuel for the boilers. **Figure 5** indicates the energy consumption, which corresponds to the amount of electricity and diesel for the year 2013. However, figures on the consumption or cost was not considered important as the compressors are not suitable for waste heat recovery. Hence, there is no potential saving expected in it. The electricity is used for production and office operation. Total cost energy consumption per year is as shown in **Table 3**. The carbon dioxide conversion factor used is 0.73KGCO2/kWh. Before the implementation of energy audit and management, the plant consumes approximately 7,884,948kWh of energy per annum based on 2012/2013 figures, costing a total of RM 2,381,742. Based on these figures the average unit cost for electricity used for the calculations is 7.4p/kWh. The data for year 2014 is only until Jun, which is semi-year. Approximately, in year 2013, the factory monthly consumption is 600,226kWh. The factory expected to reduce 48kW monthly in year 2014 or equal to 34,560kWh, which is 5% from the average monthly consumption at the earlier stage of energy management.

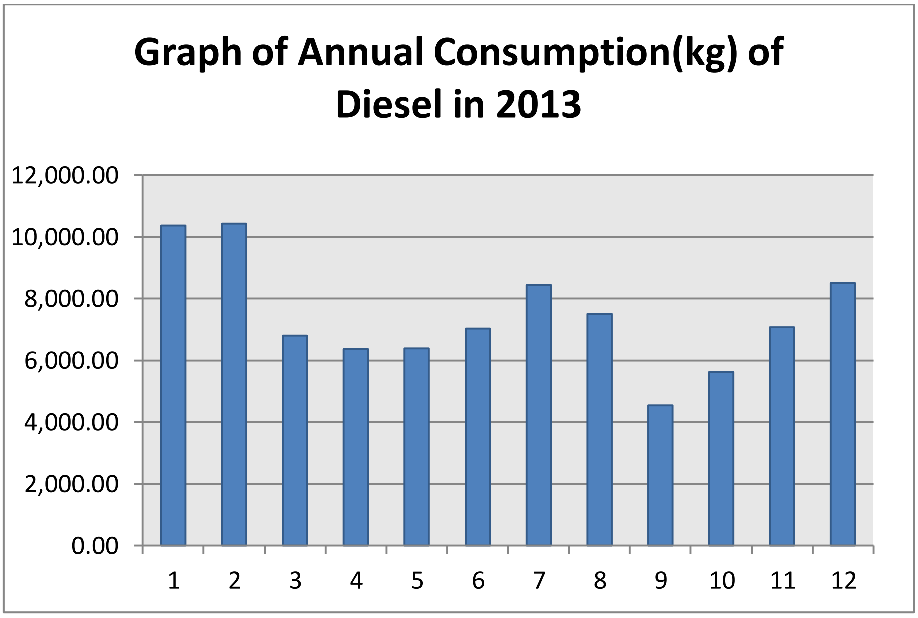


Figure 4 Graph of Annual Consumption of Diesel in 2013

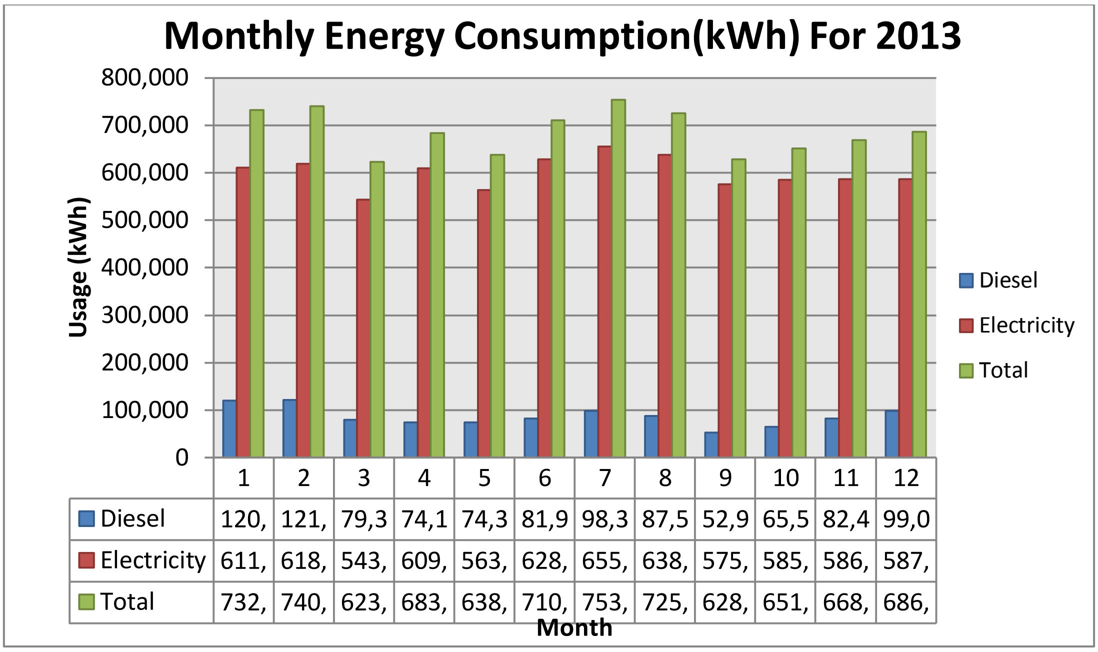


Figure 5 Monthly Energy Consumption(kWh) For 2013

	2012	2013	2014 (midyear)
Electrical (kWh)	7,149,713	7,202,718	3,505,224
Energy cost (RM)	2,340,957	2,358,312	1,235,877
Ton of CO2 per year	5,200	5,240	4,249
Average kWh per month	595809	600,226	584,204

Table 3 Total energy consumption per year

To carry out energy conservation measures, the analysis of the collected data was identified. The major consumer of electricity has to be identified. This is important to ensure the suggestions on energy management will be significant to the total consumption. First the total daily electrical consumption for this factory is collected. This data was captured using build-in power analyzer at the main incoming supply. Data was viewed on the Power Studio software. The data is from 1st July 2014 to 18th July 2014. **Table 4** is summarized the daily consumption based on specific days. The table showed that on Saturday, which is weekend, the office is not operate and most of the lighting is off. On the graph it shows reduction ¼ of the normal daily consumption. Meanwhile, on Sunday, the production area is not operate and showed another ¼ reduction. Air Handling Units(AHU) are operated 24hours in production area and some of the office. It shows that the AHU and lighting consume the most of the electricity. Beside the study on daily consumption related with production and office operation, an investigation on area wise consumption area is conducted. It is best to capture the energy usage from the overall consumption for each area. The data as in **Figure 7** showed that heating, ventilating, and air- conditioning (HVAC) system contribute 63.55% of the total consumption. The machines at the production area only contributed 13% and compressor which support the machines in production only 8%. Office area which consist of computer equipment, server, printer contributed 7%.

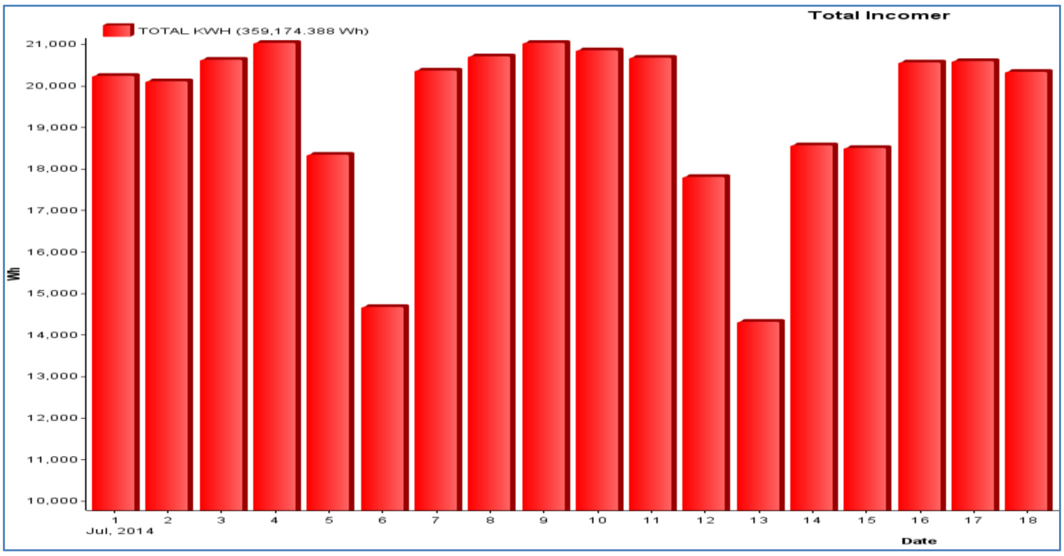


Figure 6 Total Daily Incoming (kWh)

Day	Date	AHU		Lighting		Machinery at Production Area
		P	O	P	O	
Normal Working day	1-4 7-11 16-18	/	/	/	/	/
Saturday	5,12	/	/	/	X	/
Sunday	6,13	/	/	X	X	X
Public Holiday	14,15	/	/	/	X	/

P = Production, O = Office

Table 4 Summary of Operation

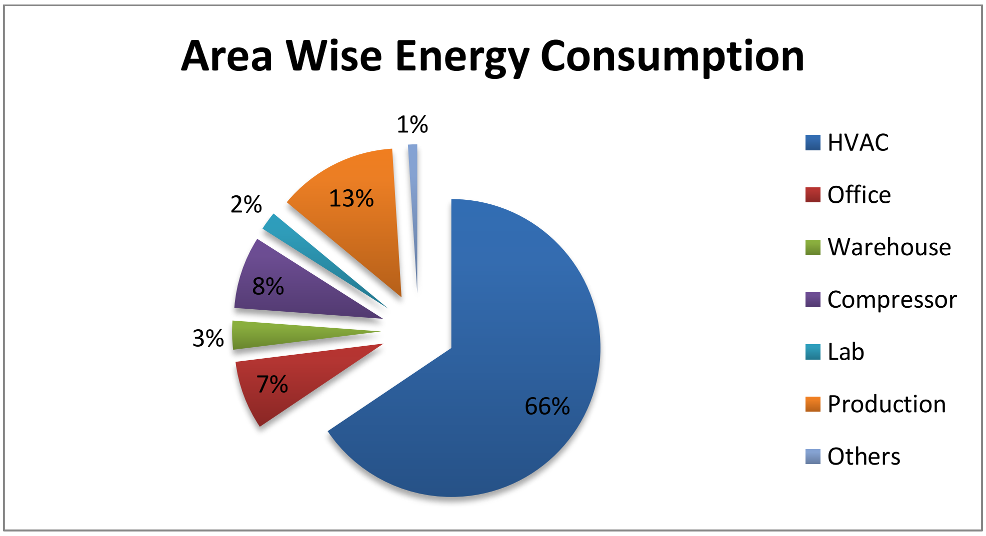


Figure 7 Area Wise Energy Consumption

4.2 Air Handling Unit (AHU)

Air handling unit (AHU), is a device used to condition and circulate air as part of a heating, ventilating, and air- conditioning (HVAC) system. Air handlers usually connect to duct work that distributes the conditioned air through the building, and returns it to the AHU. AHUs operate on various time period, some running 24 hours a day, 365 days a year, however most of the fans attached were always running at 100%. The Figure 8 shows the distribution of total energy consumption from HVAC system. There are 18 units of it in this factory.

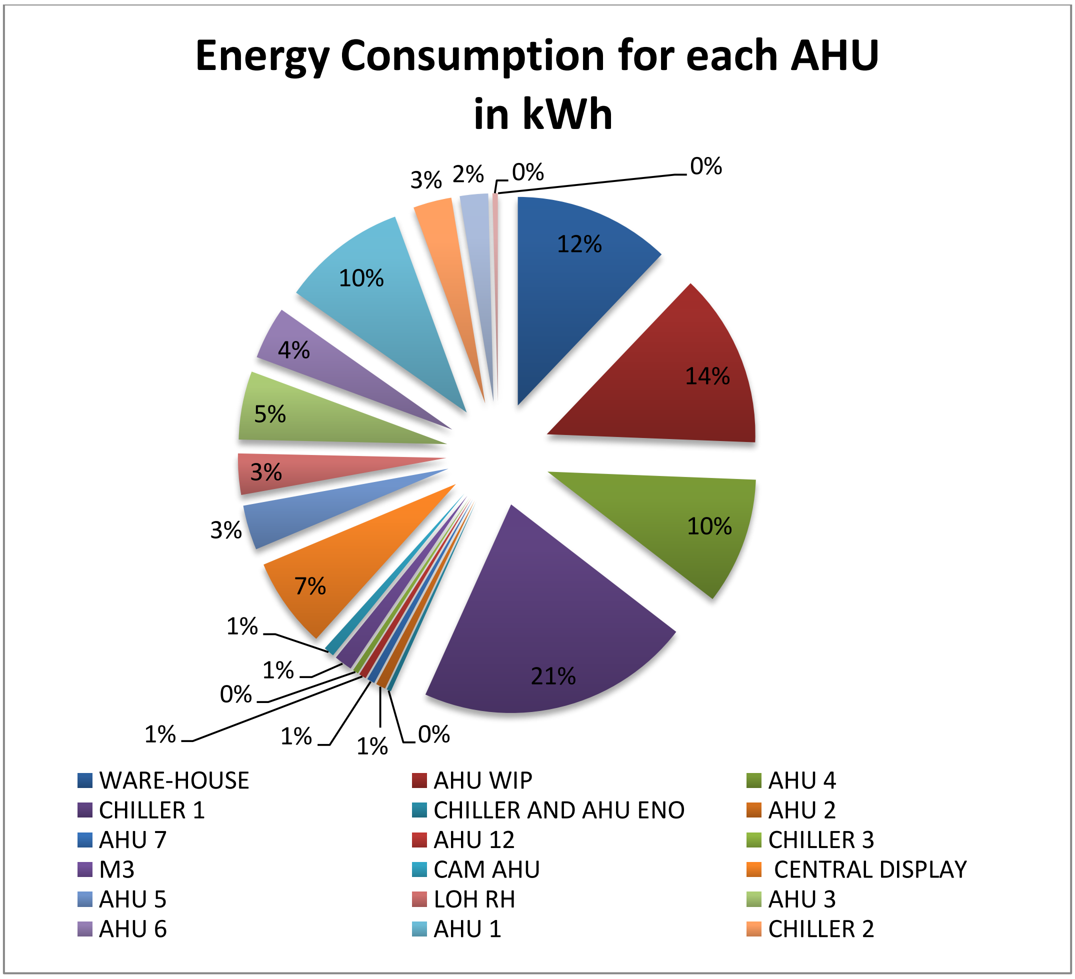


Figure 8 Energy consumption of HVAC system in kWh

4.2.1 VSD / Inverter

If the fan motors could be operated at reduced speeds, electricity consumption, carbon emissions and cost can be reduce. Thus, it was worthy of carrying out a study on efficiency of VSD for this site and also carry out a survey on others air handling units that would be suitable for variable speed controls on further savings. The use of retrofit variable speed drives (VSD) is one of the most effective technologies applied in recently.

Inverter-type air conditioners offer a more efficient alternative by 30% to 50%. In the inverter-type, the variable speed of the compressor ensures rapid cooling after start-up and attains the desired temperature quicker. It can also reduce the speed of the compressor to save energy while maintaining thermal comfort.

The following savings are guaranteed after the installation of variable speed driver(VSD) at the fan of air handling unit (AHU).

VSD for five more unit of AHU were installed in December 2013 during the shutdown period, which are AHU WIP, 6, 7, Oxy and Eno motors. The AHU start to operate with VSD in 2014. Energy change before and after of retrofit were compared to analyzed the potential of energy saving and to improve the efficiency. Figure 9-18 show the result for data captured from the power analyzer and visualize in Power Studio software. Table 5 illustrated the summarize for the data captured.

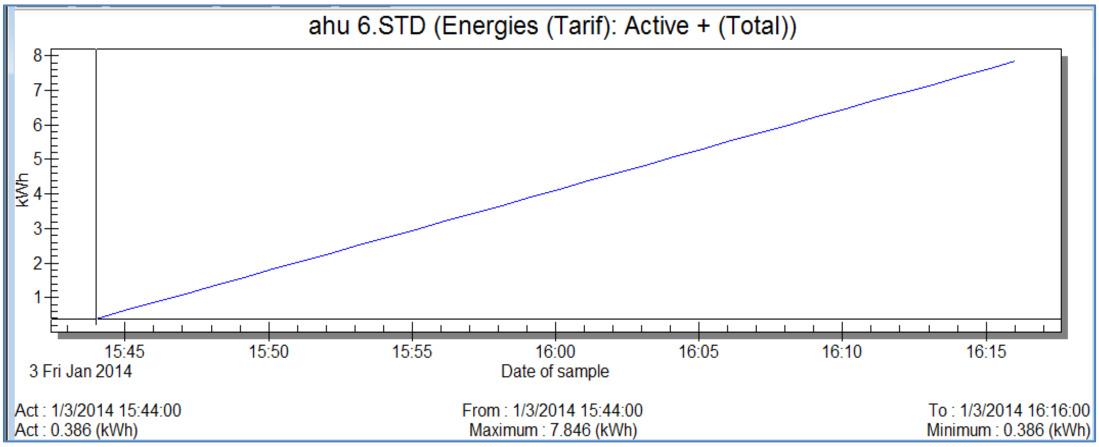


Figure 9 Data recording for AHU 6 in kWh (without VSD)

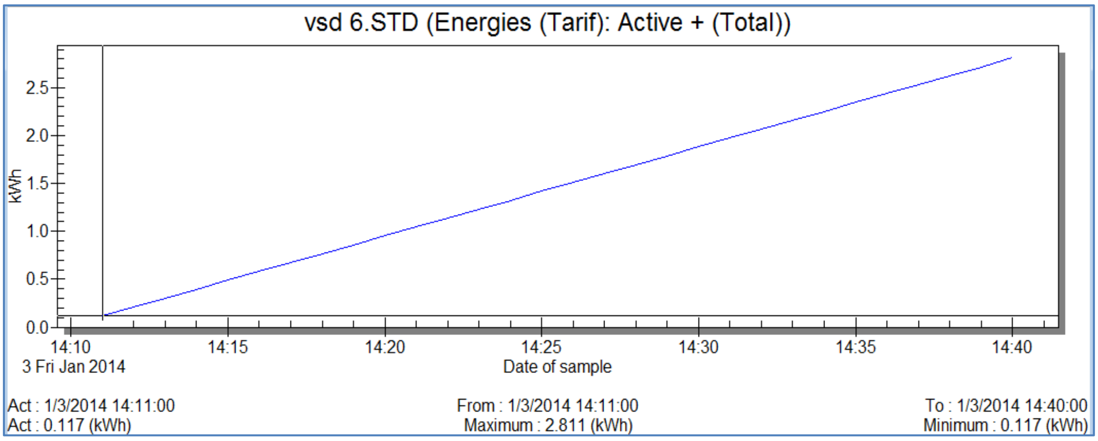


Figure 10 Data recording for AHU 6 in kWh (VSD)

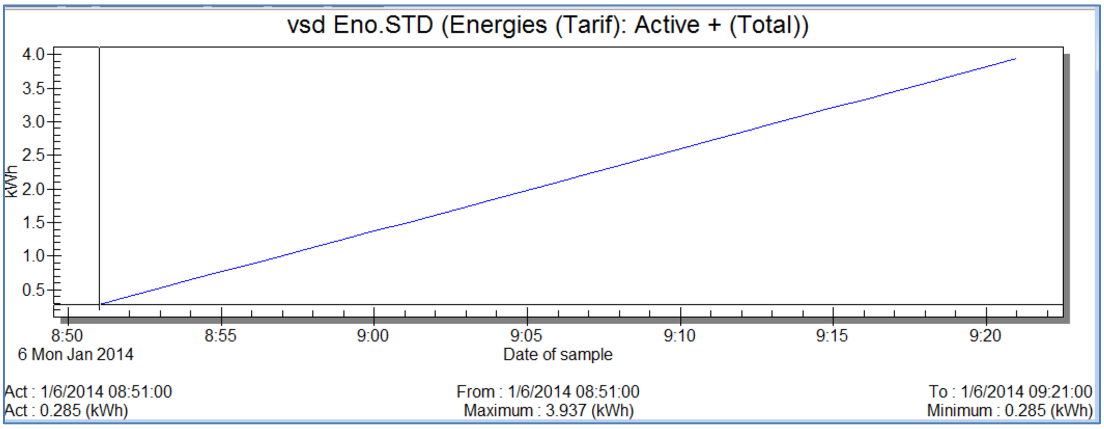


Figure 11 Data recording for AHU Eno in kWh (without VSD)

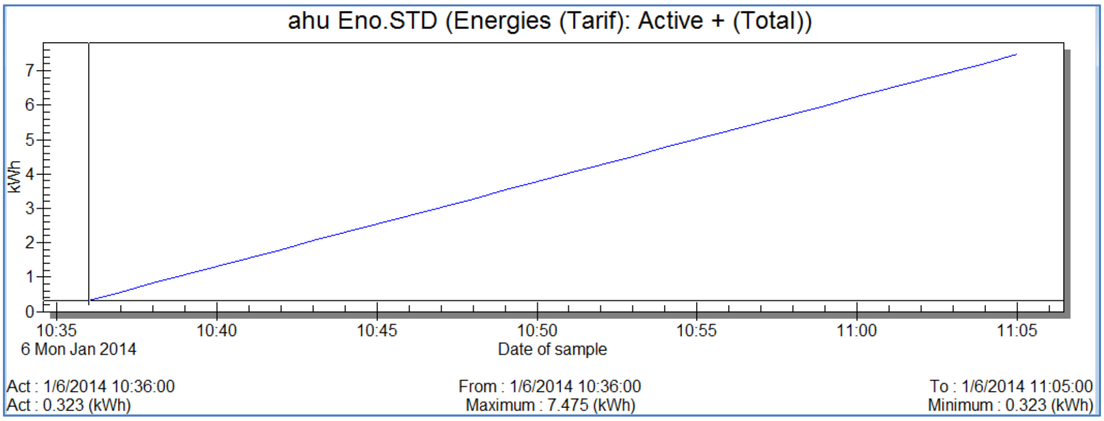


Figure 12 Data recording for AHU Eno in kWh (VSD)

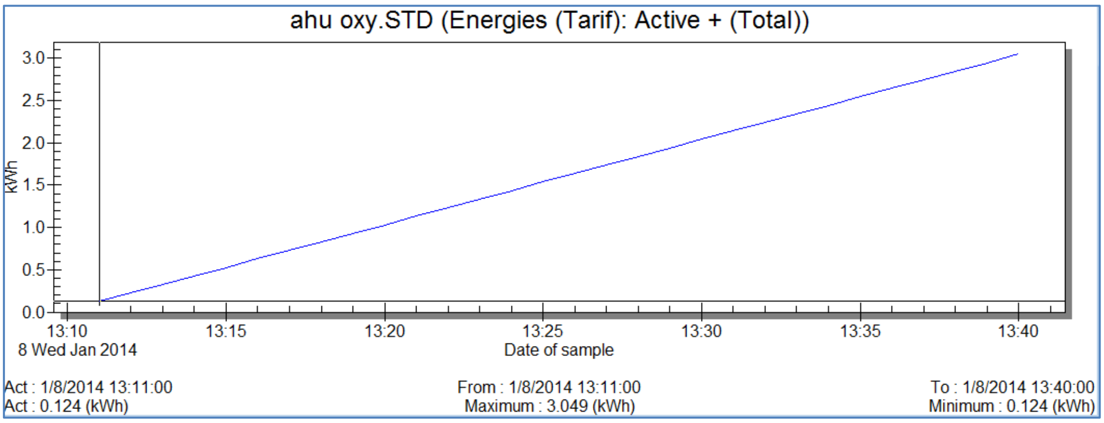


Figure 13 Data recording for AHU Oxy in kWh (without VSD)

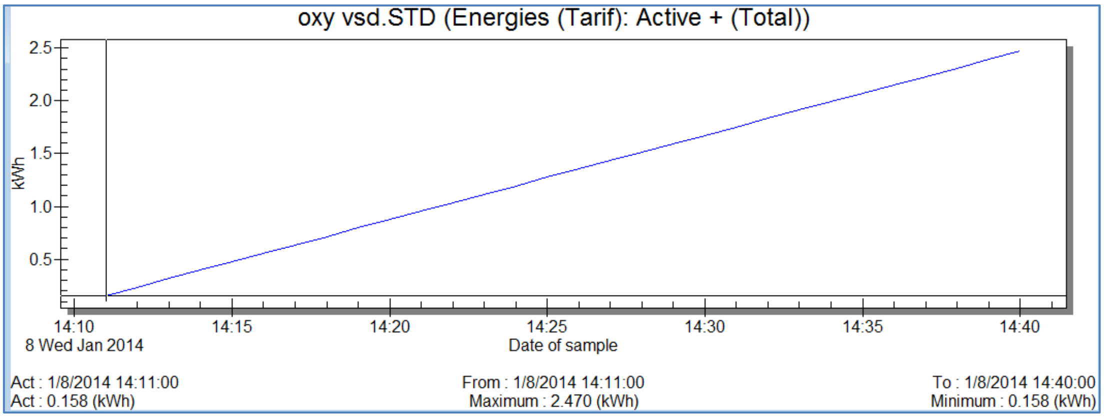


Figure 14 Data recording for AHU Oxy in kWh (VSD)

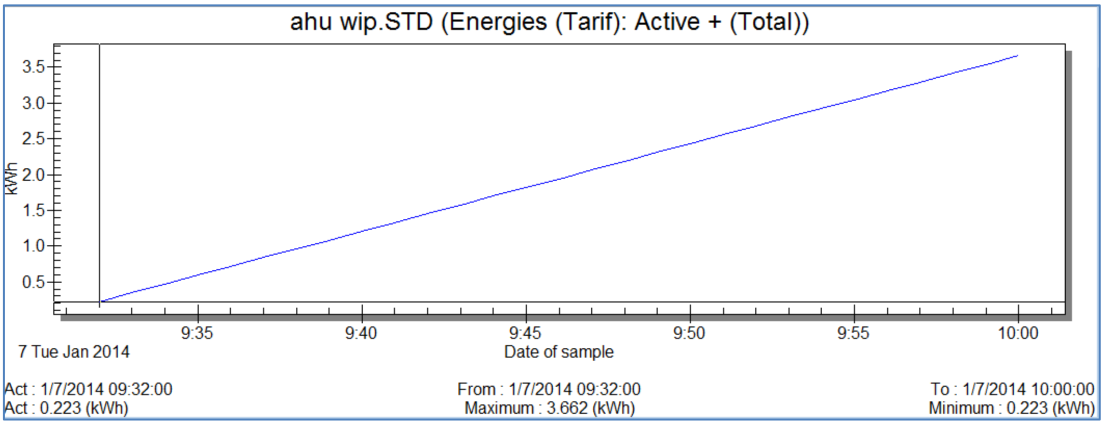


Figure 15 Data recording for AHU WIP in kWh (without VSD)

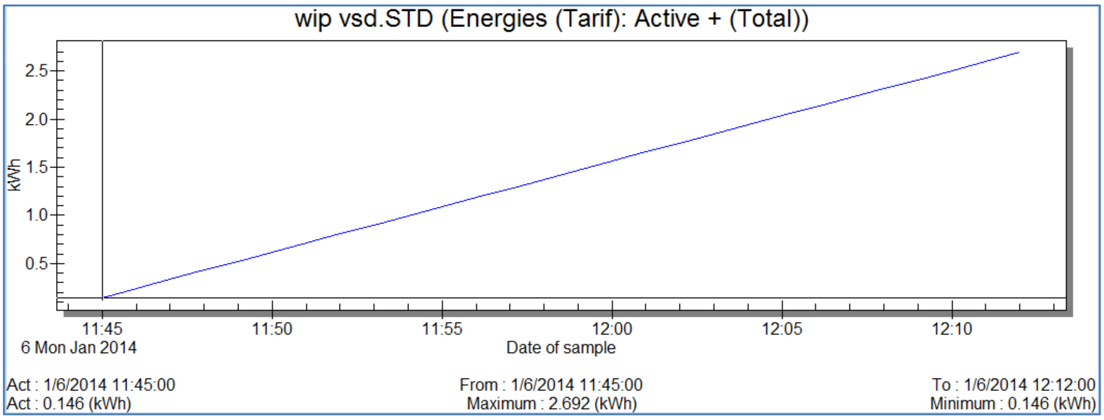


Figure 16 Data recording for AHU WIP in kWh (VSD)

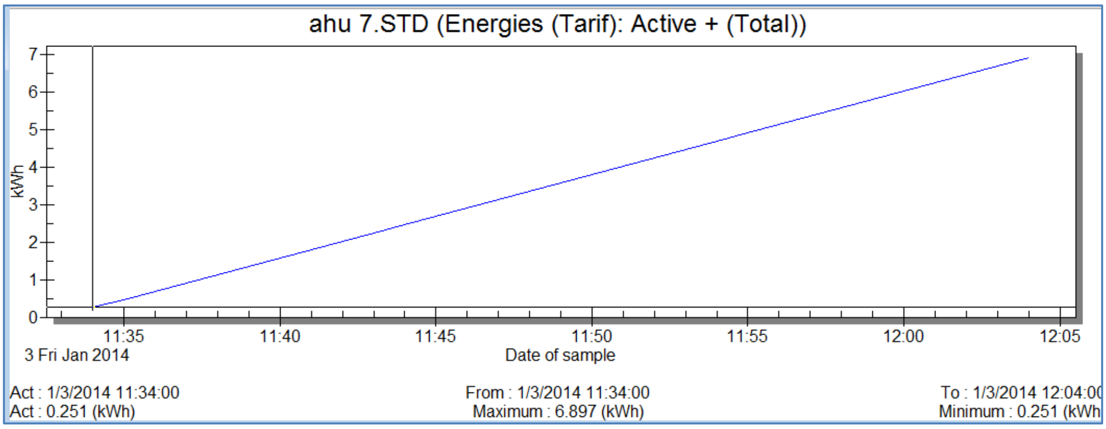


Figure 17 Data recording for AHU 7 in kWh (without VSD)

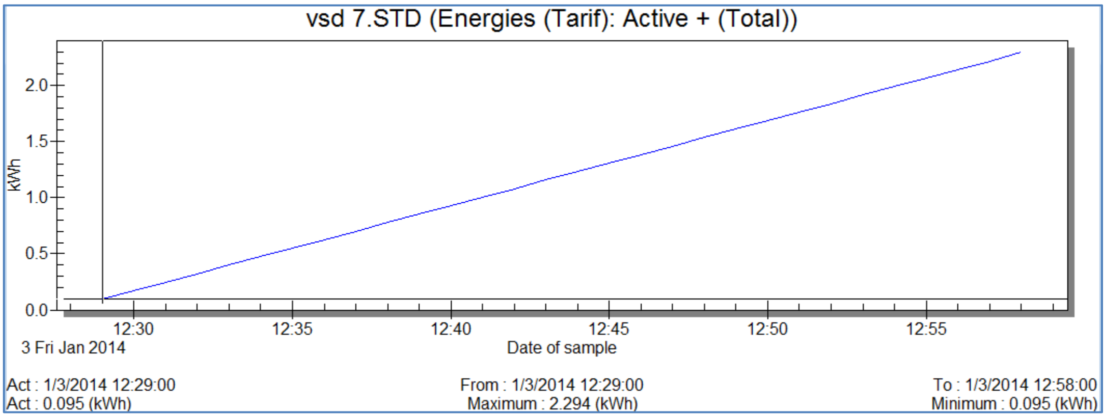


Figure 18 Data recording for AHU 7 in kWh (VSD)

AHU	Before installation / Without VSD (kWh)	After installation of VSD (kWh)
AHU WIP	3.662	2.692
AHU NO 6	7.846	2.811
AHU NO 7	6.897	2.294
AHU OXY	3.049	2.47
AHU ENO	7.475	3.937
TOTAL	**28.92**	**14.204**

Table 5 Summary of kWh recording for AHU

AHU	kWh monthly	Total RM	% of saving	Ton of CO2 yearly	Cost of VSD (RM)	Simple Payback Period
AHU WIP	3876	1169	26	33	10,300	0.73
AHU NO 6	4048	1208	64	35	22,900	1.58
AHU NO 7	3303	1018	67	28	19,600	1.60
AHU OXY	3557	1060	19	31	12,900	1.01
AHU ENO	5669	1682	47	49	19,600	0.97
TOTAL	**20453**	**6137**	**44%**	**179**		

Table 6 Energy saving potential for the installation of VSD

Table 6 illustrated the energy saving before and after retrofit. After the retrofit, the energy consumption of the AHUs for each month is decreased average by 44%.The emission of carbon footprint also predicted to be reduced yearly. The simple payback period for each installation is between 8 month to 18 month, which is good payback as within 2 years. Thus, as conclusion the installation of VSD has significant on energy saving.

4.3 Lighting system

4.3.1 Delamping

Delamping is removing unnecessary light bulbs/fixtures in areas that are producing illumination that are more than the requirement. In Malaysia, Malaysian Standard-Code Of Practice On Energy Efficiency And Use Of Renewable Energy For Non-Residential Buildings, MS 1525: 2001 is referred. In that standard, different level of luminance for different type of area. Table 6 show the suggested level of luminance for different area.

	Type	Standards MS*
luminance , Lux	Office , Hall , Library , Meeting Room	300-400 Lux
	Lift Lobby , Toilet	100 Lux
	Cafeteria , Stalls	200 Lux

Table 7 Suggested level of luminance for different area

First a lighting assessment must be made, then calculations are performed in order to meet the requirements. Lamps in the main hallway were removed yet adequate lighting levels were still maintained according to the guidelines. It is important to prioritize the safety of the worker by keeping the luminance level within the standard. The standard can be referred when conducting delamping, however the value may vary depending on external issues and the age of lamp itself. The external issue such as reflectance values, partition heights and locations must be considered. The second measure looked into the illuminance required in each room of the building relative to the tasks performed within it. The data is taken using the digital lux meter.

Figure 19 Digital Lux Meter

A survey to check on the luminance at each area is conducted. From the visit, most of the reading is above the standard level. It shows that the wastage of the energy on that area. It is advisable to delamping the bulb at certain area. Table 8, is the calculation of saving for production area by delamping 1/3 which is 400 of the existed bulb became 800 instead of 1200. Saving from this measure is 38880kWh equal to RM12441, monthly.

Unit	**1200 bulb**	**800 bulb**
A	$1200 \times 0.22A = 246$	$800 \times 0.22A = 176$
kW	$\frac{264A \times 610}{1000} = 161$	$\frac{176A \times 610}{1000} = 107$
kWh	$161 \times 24h \times 30day = 115{,}920$	$107 \times 24h \times 30day = 77{,}040$
Cost(RM)	$115{,}920 \times 0.32 = 37{,}094.40$	$77{,}040 \times 0.32 = 24{,}652.80$

Table 8 Calculation of the lamp in production area

4.3.2 Change the type of lamps

Table 11 below show the suggested lamp to replace for more saving in energy consumption. Most of the area at canteen, production and corridor uses the fluorescent tube T8(18W) and (36W). From the survey, the identified lamps are planned to be replaced.

Existed	**Suggested**
Fluorescent tube T8(18W) Fluorescent tube T8(36W)	T5(28W)
	T5(14W)
	LED(18W)
Conventional ballast(8W) Magnetic ballast	Electronic ballast (3W)
Sodium vapor lamps (250W) Incandescent lamps	CFL(23W)
Halogens	Metal halides

Table 9 Suggestion on type of lamp to be replaces

Table 12 shows test results for 28W T5 tubes as compared with 36W T8 tubes conducted by the Energy Efficiency Office (EEO) of the Electrical & Mechanical Services Department of Hong Kong .[13]

Factor	28W T5 Fluorescent	36W T8 Fluorescent
True power (W)	30.7	43.8
Life-span (hours)	10,000	3,000 to 5,000
Material content	No pollutants	10 mg mercury
Brightness (Lux)	2632	1152
Voltage (V)	227	221
Power factor	0.96	0.51
Ballast dissipation (W)	0.64	7.74

Table 10 Comparison of fluorescent tubes

4.4 Power Factor Improvement

To understand the present electrical energy scenario, power variations are monitored in both main panels for the main account of electrical usage. Figure 19 and 20 are the power factor evolution of the facility record for the year 2014, obtained from Power Studio software. From the graph, the power factor in this factory maintained within the minimum value set by TNB which is 0.85. Power factor for Main Switch Board 1(MSB1), is slightly lower than Main Switch Board 2(MSB2) because it supply to most of the production area which consist of machines with inductive motors, also lighting and power distribution board(DB).

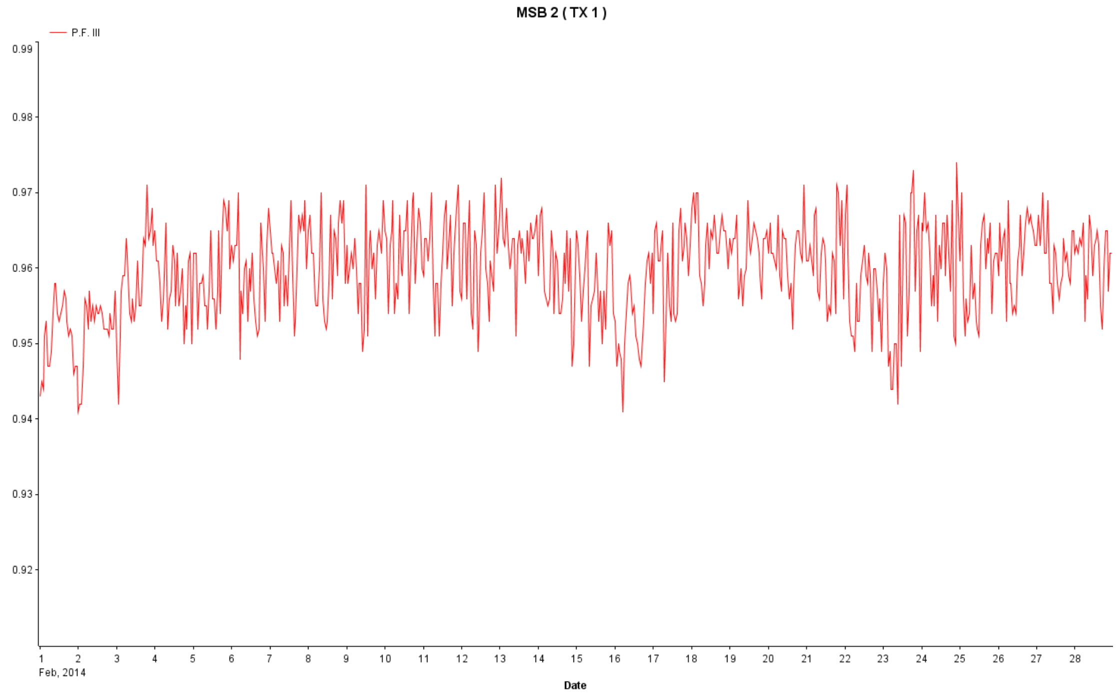


Figure 20 Power Factor Evolution along the year 2014 for Transformer No.1

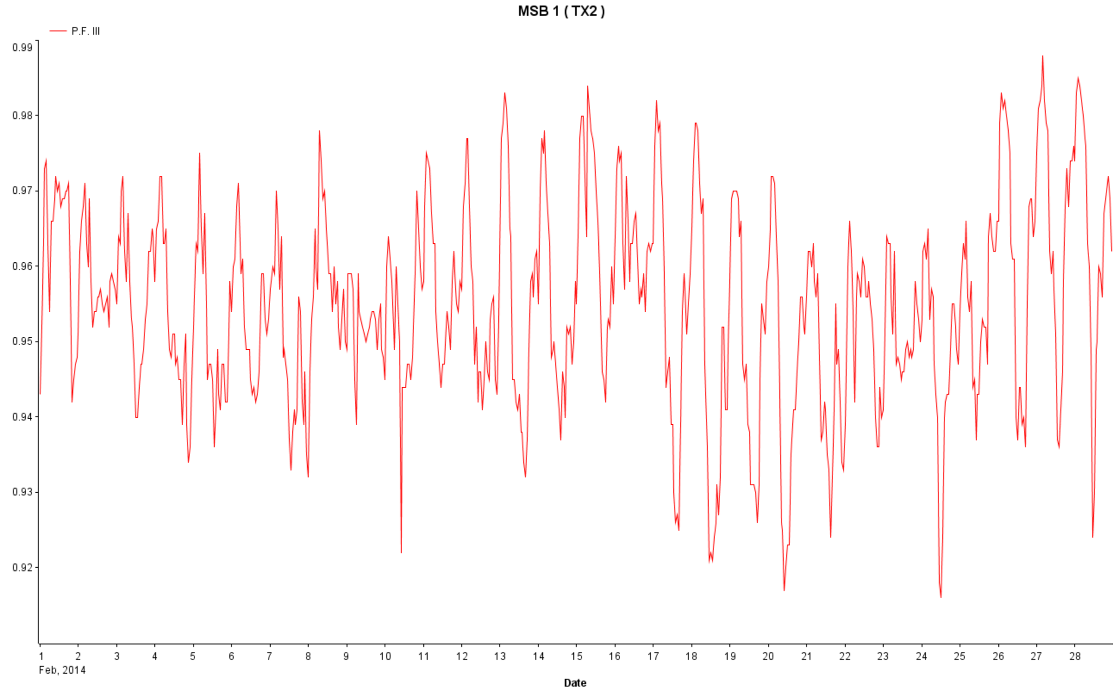


Figure 21 Power Factor Evolution along the year 2014 for Transformer No.2

Chapter 5
CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Energy audits have shown that the load in this factory was significant and that there was potential for monitoring and reducing the electricity usage thus the greenhouse gas emission as well. However, the average monthly consumption which is 584,204kWh until midyear 2014 did not achieve the targeted amount. This is because the energy audit and management just conducted on December 2013. The factory targeted to reduce 5% from the average 2012/2013 value. Until the midyear of 2014, the site managed to reduce 16,062kWh equal to 2% from targeted value. This value is achieved by implementing the VSD on five more unit of AHU. For the lighting, the factory expected to reduce another 38,880kWh from delamping and change the lamp to energy efficiency type such as 28W and 14W T5 Fluorescent or LED(18W). The data collected from the energy audit can be a guide for future planning to reduce the energy consumption.

5.2 Recommendation

The future focus on the energy management for this factory based on the audit will be concentrated on AHU and lighting. Some of the measures that can be considered are: Replacing the air conditioning refrigerant from R22 to Cold22. It is environmental friendly and can save the electricity up to 20%. Occupancy sensors can be installed in rooms to switch off air-conditioners when they detect no movement for at least five minutes. Additional energy savings can be achieved by adjusting the indoor set point temperature to just 3°C below the ambient temperature. Besides that, it is also essential to ensure regular maintenance of the air conditioning units so that their efficiency is not affected and their lifetime is extended.

For the lighting, occupancy sensor also can be installed at the office building. Installation of voltage stabilizer can maintains constant voltage, irrespective of voltage fluctuations. The stable and constant voltage also reduces the damage rate of the lamps. For the office equipment such as personal computer, the auto shut down within the specific time can be set up. All the recommendations are possible to be implemented provided that the management of the factory willing to invest and funding the project.

REFERENCES

[1] M. E. I. Hub. (2011). Available: http://meih.st.gov.my/statistics

[2] T. F. o. E. i. Malaysia. (2012, The Future of Energy in Malaysia. Available: http://www.kettha.gov.my/en/content/future-energy-malaysia

[3] Energy Commission Malaysia, "Efficient Management of Electrical Energy Regulations ," *ST*, 2008.

[4] U. S. E. I. Administration. Country Analysis Briefs. Available: http://www.eia.gov/cabs/Malaysia/Full.html

[5] U. S. E. I. Agency, "Total Carbon Dioxide Emissions from the Consumption of Energy," 2011.

[6] E. Ang, "Reducing Our Carbon Footprint," in The Star Online, ed, 2010.

[7] "Najib renews pledge for a greener Malaysia," in Borneo Post Online, ed, 2013.

[8] Gomes, J.; Coelho, D.; Valdez, M., "Energy audit in a school building technology, professional and Artistic School of Pombal," *Energetics (IYCE), Proceedings of the 2011 3rd International Youth Conference on* , vol., no., pp.1,6, 7-9 July 2011

[9] Mohit, O.K.; Oree, V., "Assessing the energy savings potential in public buildings through retrofit measures in tropical climates — A case study in Mauritius," *AFRICON, 2013* , vol., no., pp.1,5, 9-12 Sept. 2013

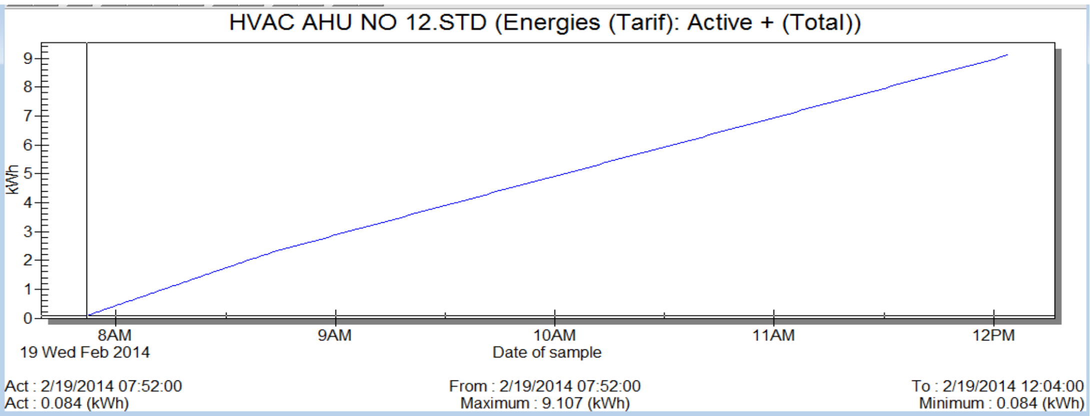
[10] Xin Wang; Chen Huang; Wuwei Cao, " Energy Audit of Building: A Case Study of A Commercial Building in Shanghai," *Power and Energy Engineering Conference (APPEEC), 2010 Asia-Pacific* , vol., no., pp.1,4, 28-31 March 2010

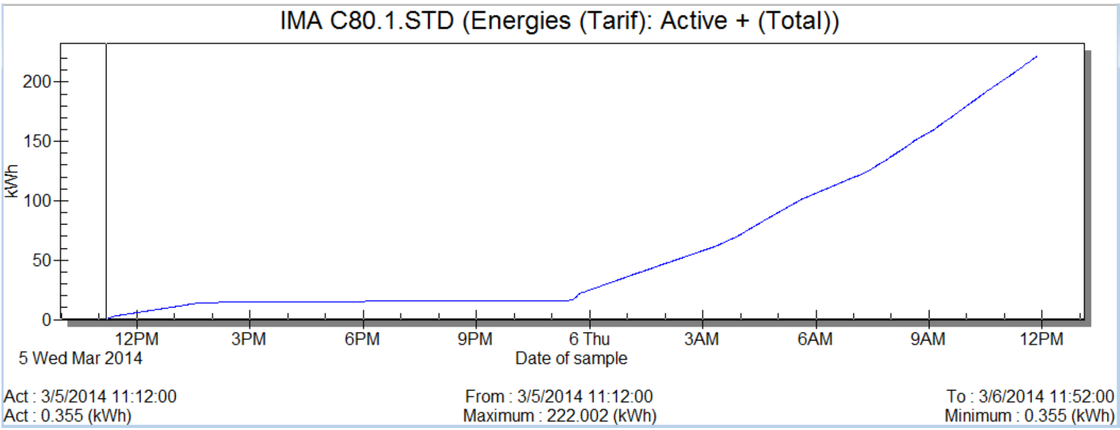
[11] Singh, H.; Seera, M.; Mohamad Idin, M.A., "Electrical energy audit in a Malaysian university - a case study," *Power and Energy (PECon), 2012 IEEE International Conference on* , vol., no., pp.616,619, 2-5 Dec. 2012

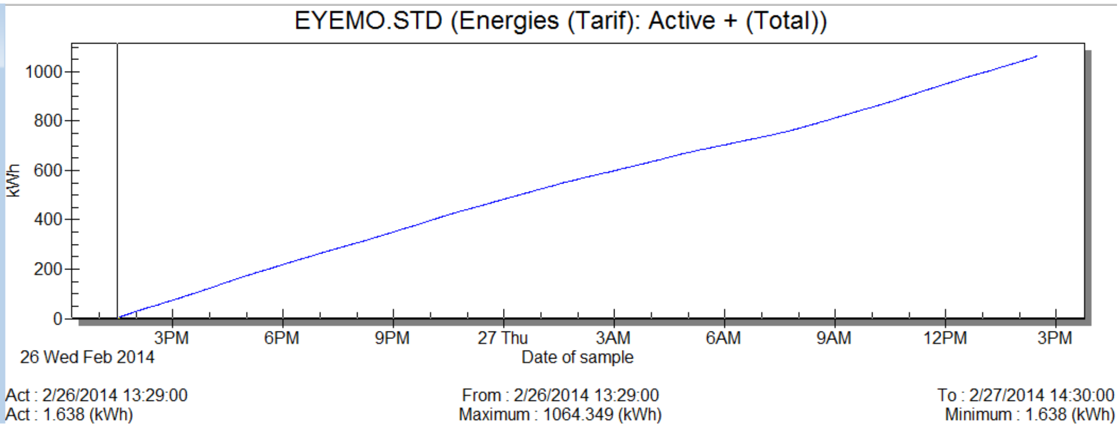
[12] Dahlan, N.Y.; Shaari, M.S.; Putra, T.A.N.T.; Mohd Shokri, S.M.; Mohammad, H., "Energy and environmental audit for Bangunan Menara Seri Wilayah and Bangunan Kastam, Putrajaya: Analysis and recommendations,"*Clean Energy and Technology (CEAT), 2013 IEEE Conference on* , vol., no., pp.500,505, 18-20 Nov. 2013

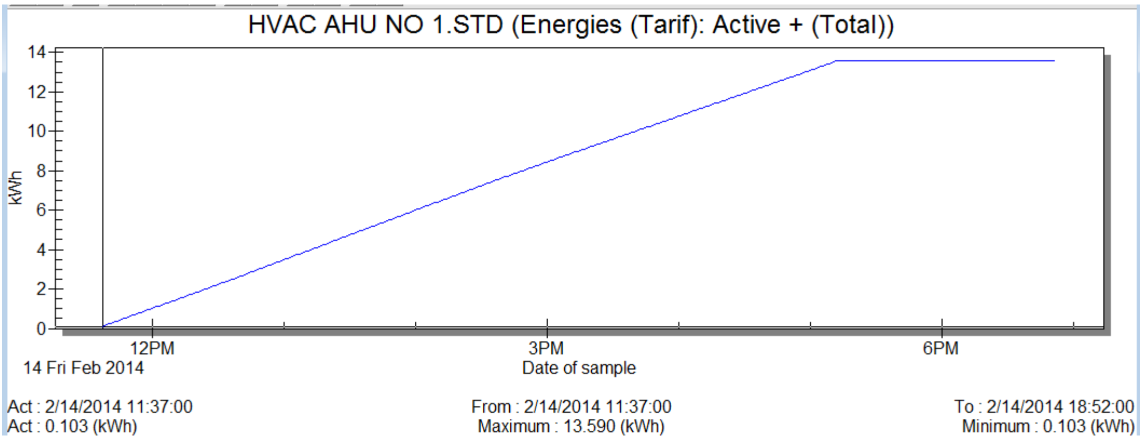
[13] I. Martin, and K.T. Wu, “Energy Efficiency Office,” Electrical and Mechanical Services Department of Hong Kong.

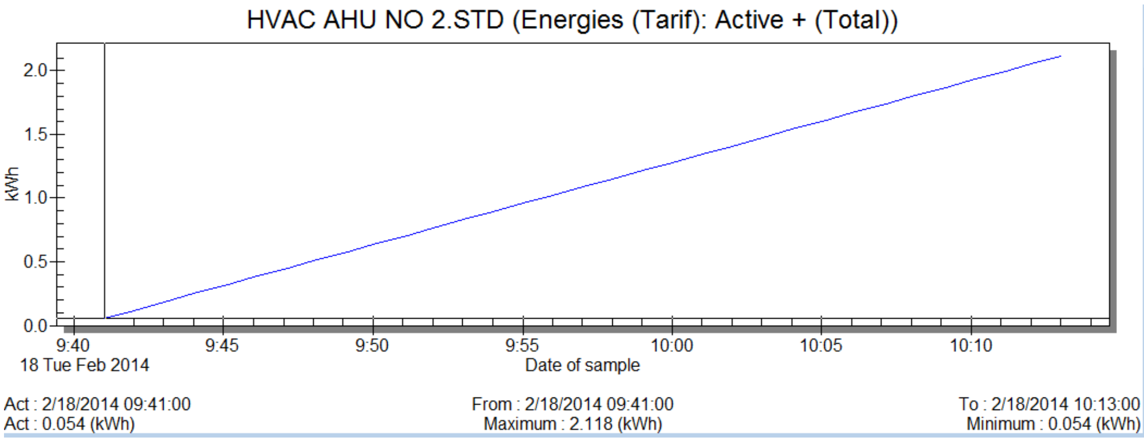
APPENDIX A

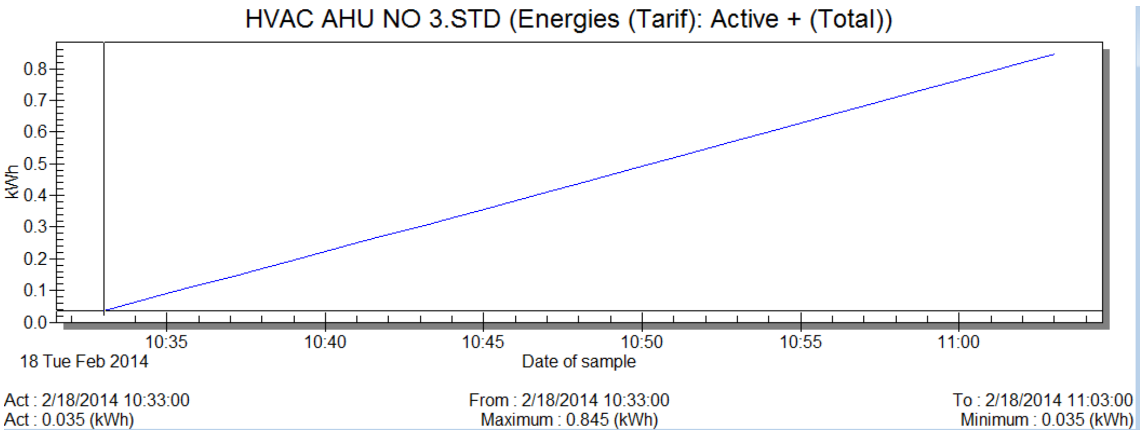

HVAC AHU NO 12.STD (Energies (Tarif): Active + (Total))
kWh
8AM
19 Wed Feb 2014
9AM
10AM
Date of sample
11AM
12PM
Act : 2/19/2014 07:52:00
Act : 0.084 (kWh)
From : 2/19/2014 07:52:00
Maximum : 9.107 (kWh)
To : 2/19/2014 12:04:00
Minimum : 0.084 (kWh)

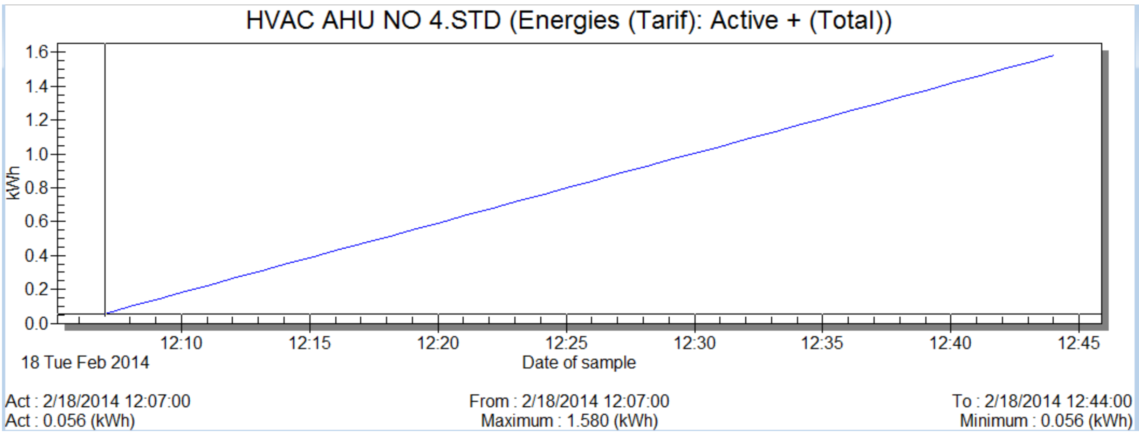

IMA C80.1.STD (Energies (Tarif): Active + (Total))
kWh
12PM
5 Wed Mar 2014
3PM
6PM
9PM
6 Thu
Date of sample
3AM
6AM
9AM
12PM
Act : 3/5/2014 11:12:00
Act : 0.355 (kWh)
From : 3/5/2014 11:12:00
Maximum : 222.002 (kWh)
To : 3/6/2014 11:52:00
Minimum : 0.355 (kWh)

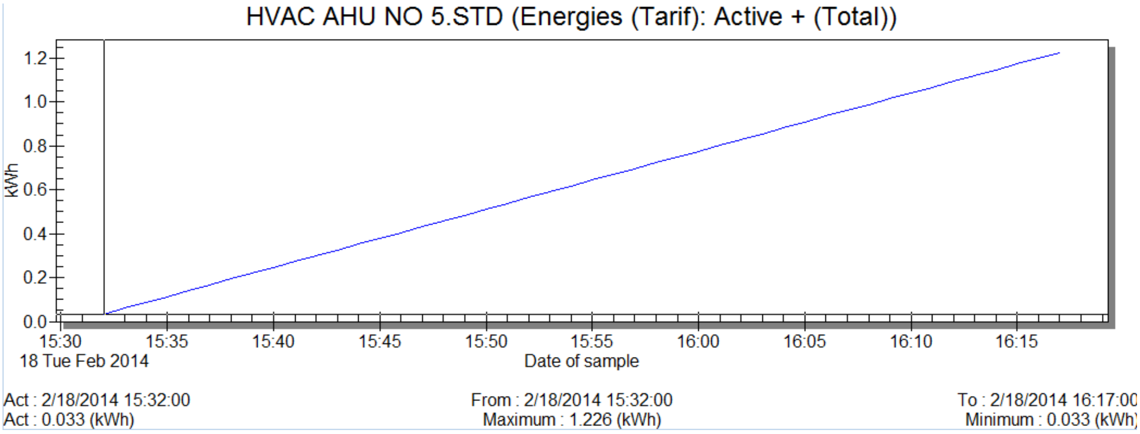

EYEMO.STD (Energies (Tarif): Active + (Total))
kWh
3PM
26 Wed Feb 2014
6PM
9PM
27 Thu
Date of sample
3AM
6AM
9AM
12PM
3PM
Act : 2/26/2014 13:29:00
Act : 1.638 (kWh)
From : 2/26/2014 13:29:00
Maximum : 1064.349 (kWh)
To : 2/27/2014 14:30:00
Minimum : 1.638 (kWh)

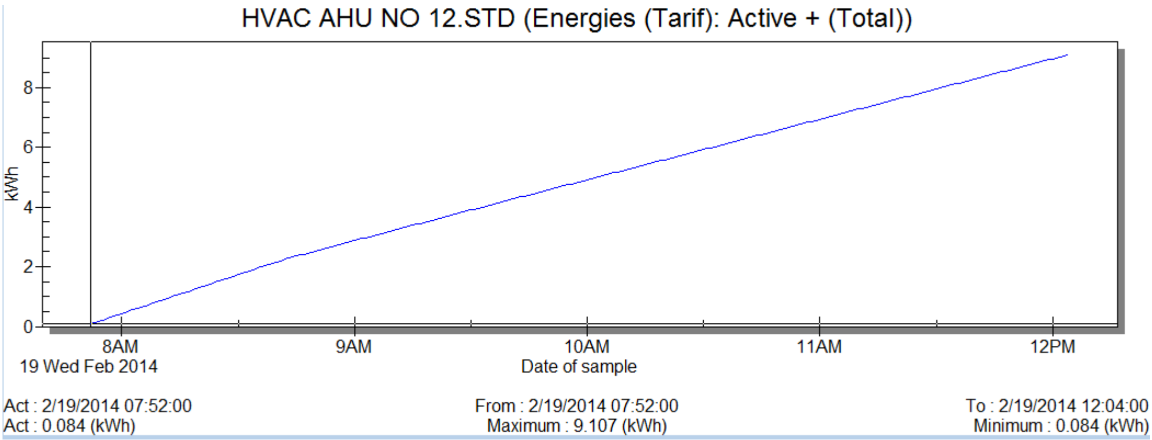

HVAC AHU NO 1.STD (Energies (Tarif): Active + (Total))
kWh
0
2
4
6
8
10
12
14
12PM
3PM
6PM
14 Fri Feb 2014
Date of sample
Act : 2/14/2014 11:37:00
Act : 0.103 (kWh)
From : 2/14/2014 11:37:00
Maximum : 13.590 (kWh)
To : 2/14/2014 18:52:00
Minimum : 0.103 (kWh)

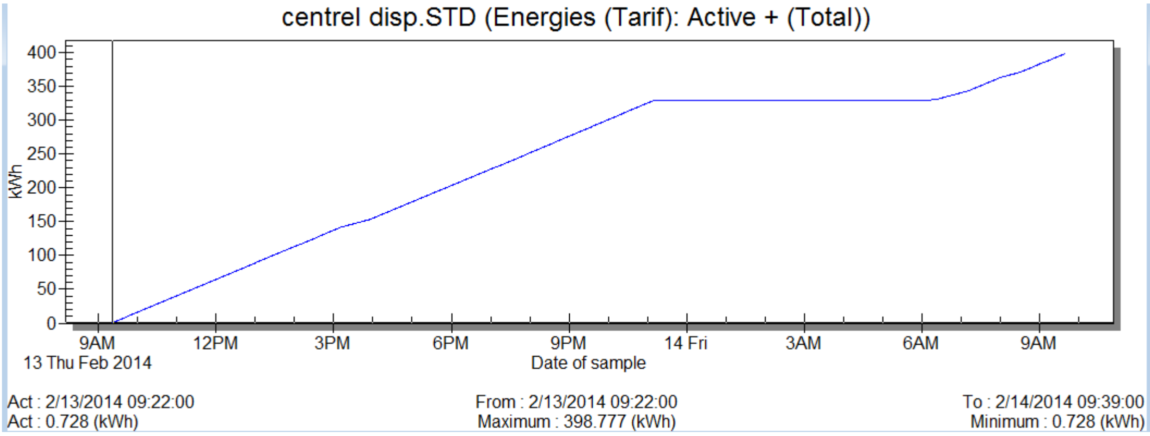

HVAC AHU NO 2.STD (Energies (Tarif): Active + (Total))
kWh
0.0
0.5
1.0
1.5
2.0
9:40
9:45
9:50
9:55
10:00
10:05
10:10
18 Tue Feb 2014
Date of sample
Act : 2/18/2014 09:41:00
Act : 0.054 (kWh)
From : 2/18/2014 09:41:00
Maximum : 2.118 (kWh)
To : 2/18/2014 10:13:00
Minimum : 0.054 (kWh)

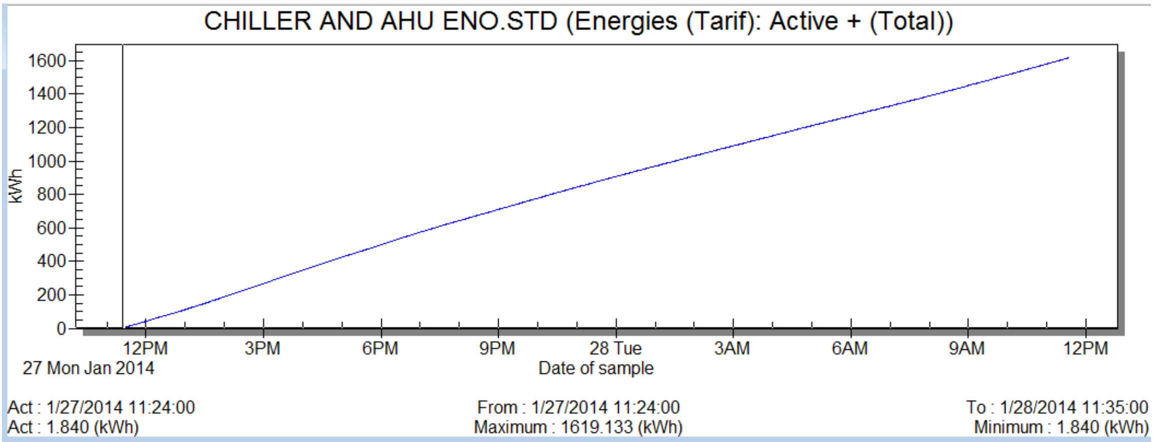

HVAC AHU NO 3.STD (Energies (Tarif): Active + (Total))
kWh
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
10:35
10:40
10:45
10:50
10:55
11:00
18 Tue Feb 2014
Date of sample
Act : 2/18/2014 10:33:00
Act : 0.035 (kWh)
From : 2/18/2014 10:33:00
Maximum : 0.845 (kWh)
To : 2/18/2014 11:03:00
Minimum : 0.035 (kWh)

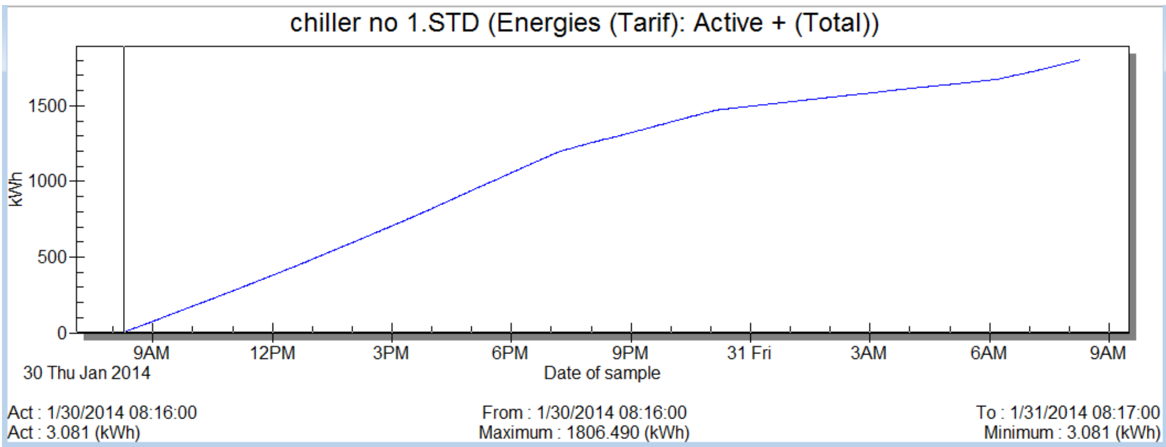

HVAC AHU NO 4.STD (Energies (Tarif): Active + (Total))
kWh
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
12:10
12:15
12:20
12:25
12:30
12:35
12:40
12:45
18 Tue Feb 2014
Date of sample
Act : 2/18/2014 12:07:00
Act : 0.056 (kWh)
From : 2/18/2014 12:07:00
Maximum : 1.580 (kWh)
To : 2/18/2014 12:44:00
Minimum : 0.056 (kWh)

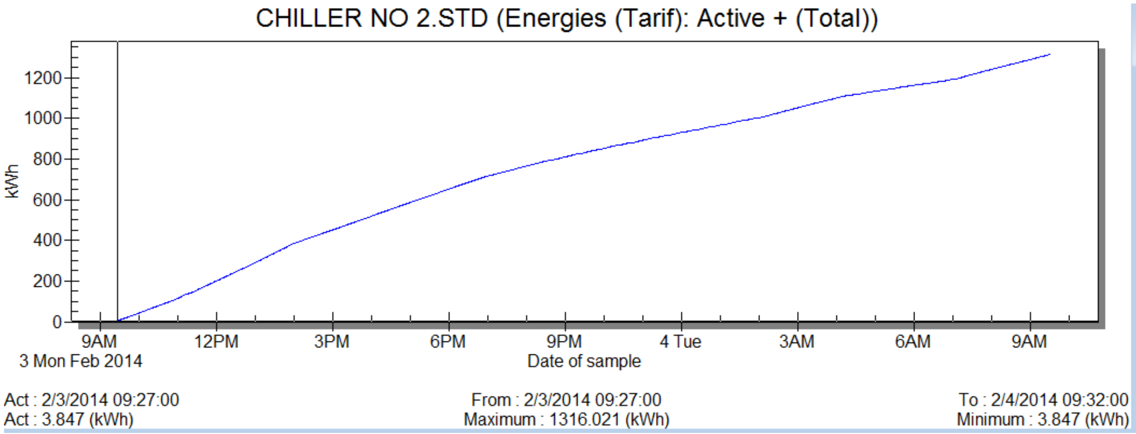

HVAC AHU NO 5.STD (Energies (Tarif): Active + (Total))
kWh
1.2
1.0
0.8
0.6
0.4
0.2
0.0
15:30
15:35
15:40
15:45
15:50
15:55
16:00
16:05
16:10
16:15
18 Tue Feb 2014
Date of sample
Act : 2/18/2014 15:32:00
Act : 0.033 (kWh)
From : 2/18/2014 15:32:00
Maximum : 1.226 (kWh)
To : 2/18/2014 16:17:00
Minimum : 0.033 (kWh)

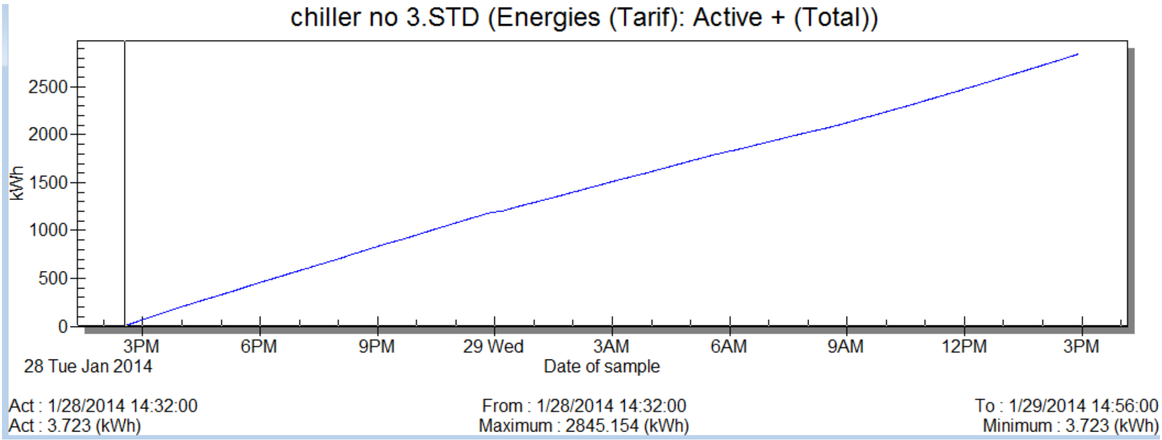

HVAC AHU NO 12.STD (Energies (Tarif): Active + (Total))
kWh
8
6
4
2
0
8AM
9AM
10AM
11AM
12PM
19 Wed Feb 2014
Date of sample
Act : 2/19/2014 07:52:00
Act : 0.084 (kWh)
From : 2/19/2014 07:52:00
Maximum : 9.107 (kWh)
To : 2/19/2014 12:04:00
Minimum : 0.084 (kWh)

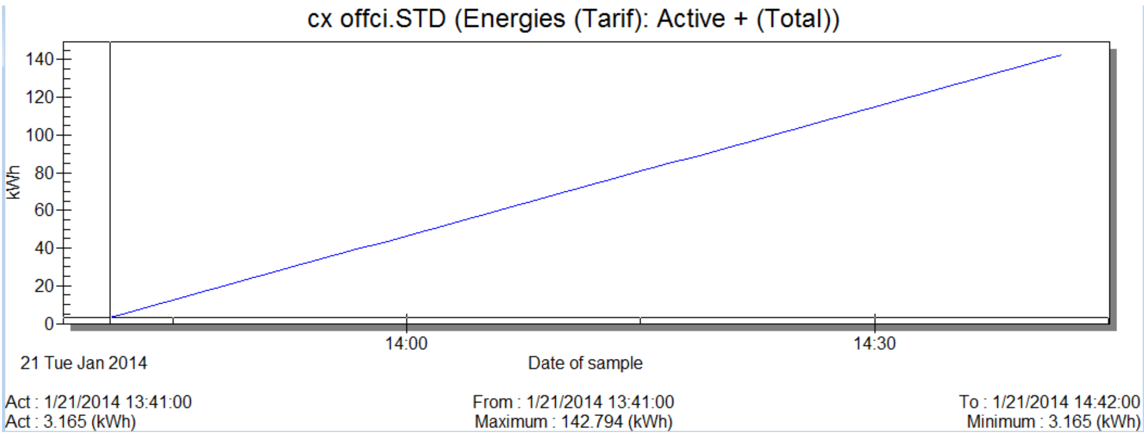

centrel disp.STD (Energies (Tarif): Active + (Total))
kWh
400
350
300
250
200
150
100
50
0
9AM
12PM
3PM
6PM
9PM
14 Fri
3AM
6AM
9AM
13 Thu Feb 2014
Date of sample
Act : 2/13/2014 09:22:00
Act : 0.728 (kWh)
From : 2/13/2014 09:22:00
Maximum : 398.777 (kWh)
To : 2/14/2014 09:39:00
Minimum : 0.728 (kWh)

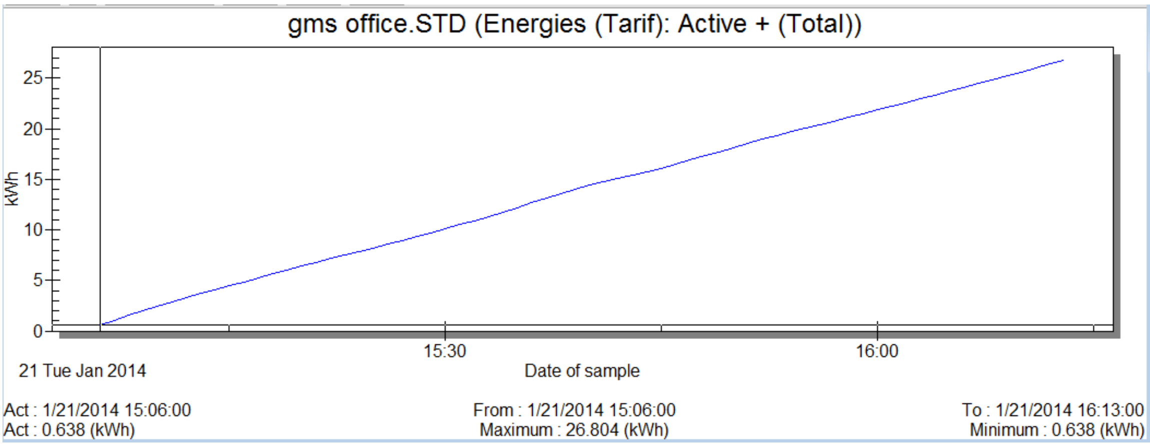

CHILLER AND AHU ENO.STD (Energies (Tarif): Active + (Total))
kWh
1600
1400
1200
1000
800
600
400
200
0
12PM
3PM
6PM
9PM
28 Tue
3AM
6AM
9AM
12PM
27 Mon Jan 2014
Date of sample
Act : 1/27/2014 11:24:00
Act : 1.840 (kWh)
From : 1/27/2014 11:24:00
Maximum : 1619.133 (kWh)
To : 1/28/2014 11:35:00
Minimum : 1.840 (kWh)

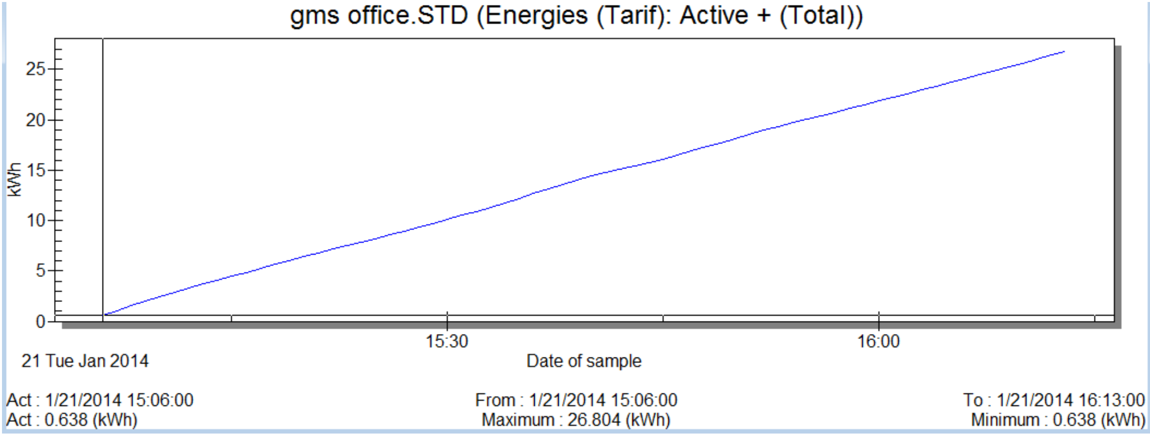

chiller no 1.STD (Energies (Tarif): Active + (Total))
kWh
1500
1000
500
0
9AM
12PM
3PM
6PM
9PM
31 Fri
3AM
6AM
9AM
30 Thu Jan 2014
Date of sample
Act : 1/30/2014 08:16:00
Act : 3.081 (kWh)
From : 1/30/2014 08:16:00
Maximum : 1806.490 (kWh)
To : 1/31/2014 08:17:00
Minimum : 3.081 (kWh)

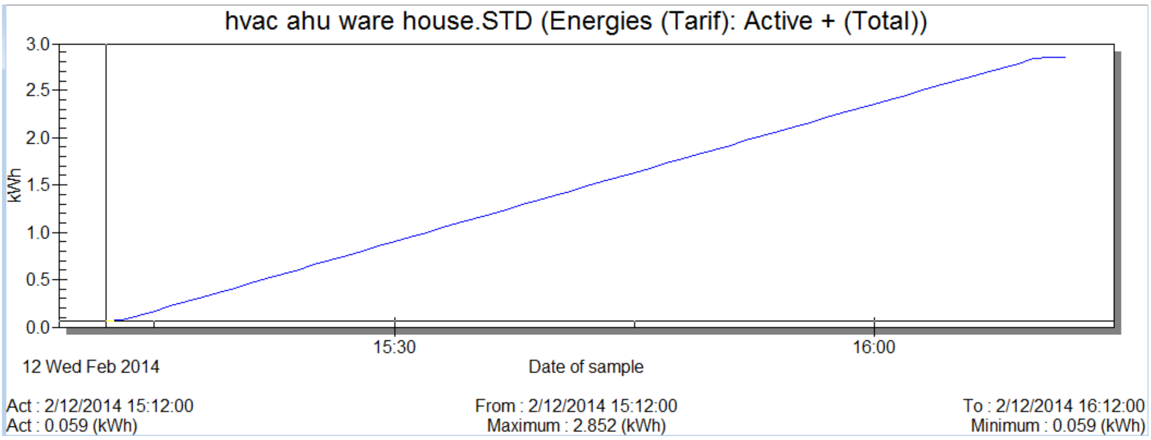

CHILLER NO 2.STD (Energies (Tarif): Active + (Total))
kWh
1200
1000
800
600
400
200
0
9AM
12PM
3PM
6PM
9PM
4 Tue
3AM
6AM
9AM
3 Mon Feb 2014
Date of sample
Act : 2/3/2014 09:27:00
Act : 3.847 (kWh)
From : 2/3/2014 09:27:00
Maximum : 1316.021 (kWh)
To : 2/4/2014 09:32:00
Minimum : 3.847 (kWh)

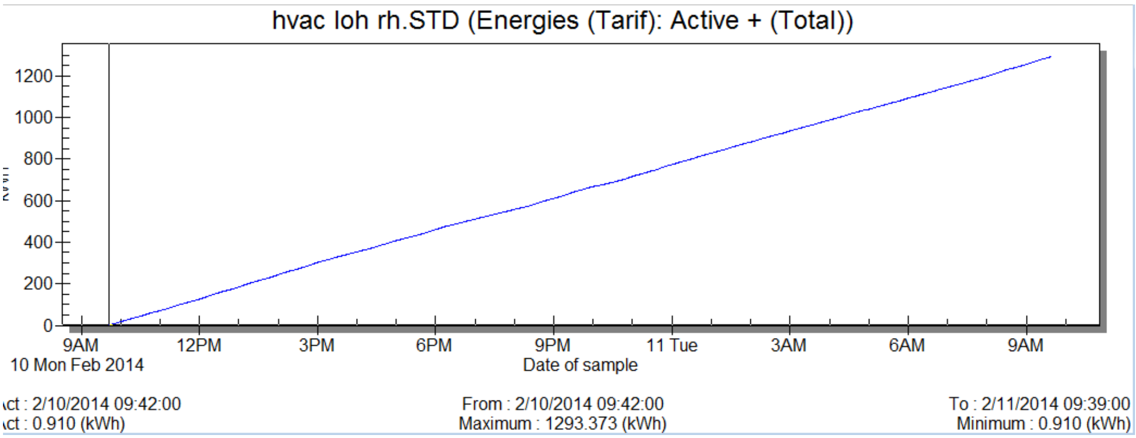

chiller no 3.STD (Energies (Tarif): Active + (Total))
kWh
2500
2000
1500
1000
500
0
3PM
6PM
9PM
29 Wed
3AM
6AM
9AM
12PM
3PM
28 Tue Jan 2014
Date of sample
Act : 1/28/2014 14:32:00
Act : 3.723 (kWh)
From : 1/28/2014 14:32:00
Maximum : 2845.154 (kWh)
To : 1/29/2014 14:56:00
Minimum : 3.723 (kWh)

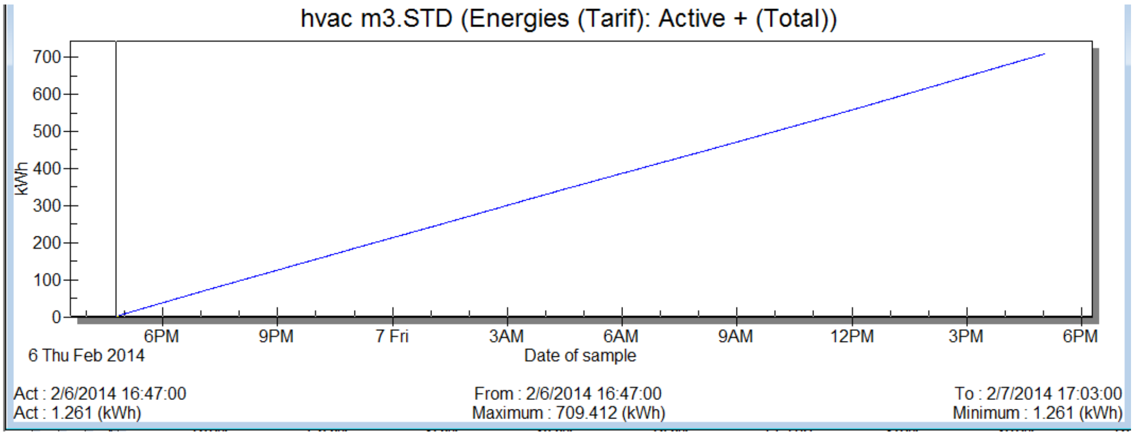

cx offci.STD (Energies (Tarif): Active + (Total))
kWh
140
120
100
80
60
40
20
0
14:00
14:30
21 Tue Jan 2014
Date of sample
Act : 1/21/2014 13:41:00
Act : 3.165 (kWh)
From : 1/21/2014 13:41:00
Maximum : 142.794 (kWh)
To : 1/21/2014 14:42:00
Minimum : 3.165 (kWh)

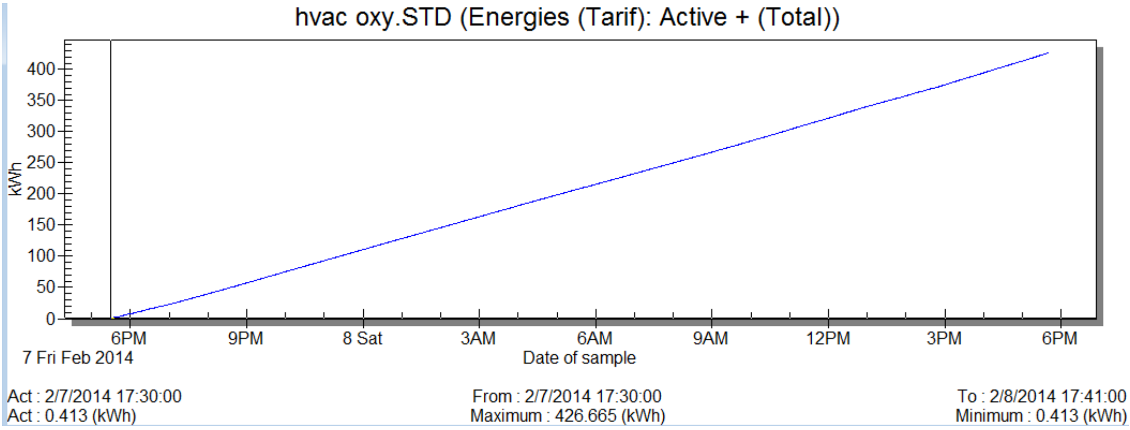

gms office.STD (Energies (Tarif): Active + (Total))
kWh
0
5
10
15
20
25
15:30
16:00
21 Tue Jan 2014
Date of sample
Act : 1/21/2014 15:06:00
Act : 0.638 (kWh)
From : 1/21/2014 15:06:00
Maximum : 26.804 (kWh)
To : 1/21/2014 16:13:00
Minimum : 0.638 (kWh)

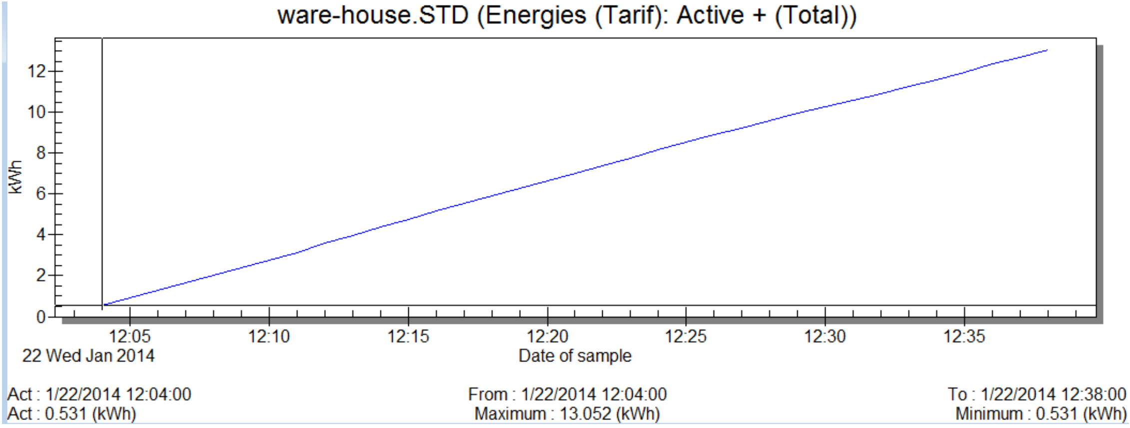

gms office.STD (Energies (Tarif): Active + (Total))
kWh
0
5
10
15
20
25
15:30
16:00
21 Tue Jan 2014
Date of sample
Act : 1/21/2014 15:06:00
Act : 0.638 (kWh)
From : 1/21/2014 15:06:00
Maximum : 26.804 (kWh)
To : 1/21/2014 16:13:00
Minimum : 0.638 (kWh)

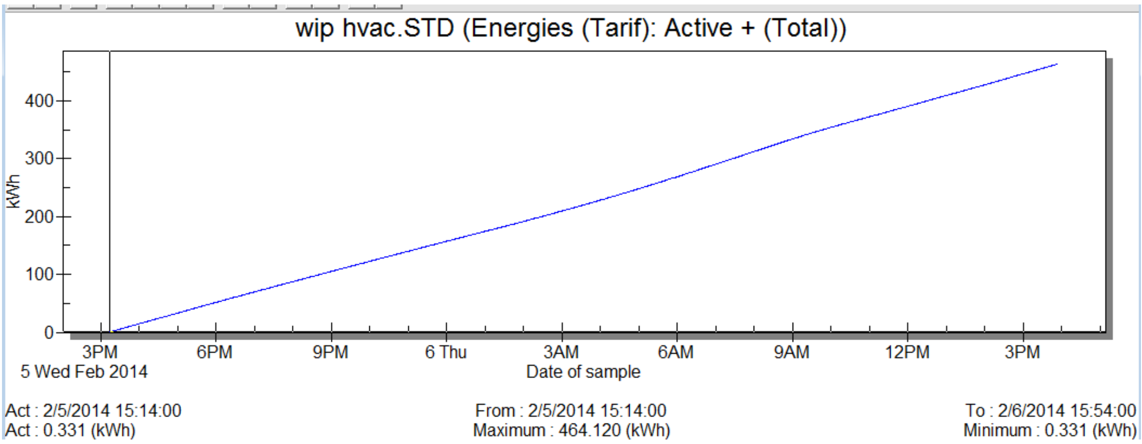

hvac ahu ware house.STD (Energies (Tarif): Active + (Total))
kWh
0.0
0.5
1.0
1.5
2.0
2.5
3.0
15:30
16:00
12 Wed Feb 2014
Date of sample
Act : 2/12/2014 15:12:00
Act : 0.059 (kWh)
From : 2/12/2014 15:12:00
Maximum : 2.852 (kWh)
To : 2/12/2014 16:12:00
Minimum : 0.059 (kWh)


hvac loh rh.STD (Energies (Tarif): Active + (Total))
1200
1000
800
600
400
200
0
9AM
12PM
3PM
6PM
9PM
11 Tue
3AM
6AM
9AM
10 Mon Feb 2014
Date of sample
ct : 2/10/2014 09:42:00
ct : 0.910 (kWh)
From : 2/10/2014 09:42:00
Maximum : 1293.373 (kWh)
To : 2/11/2014 09:39:00
Minimum : 0.910 (kWh)


hvac m3.STD (Energies (Tarif): Active + (Total))
kWh
700
600
500
400
300
200
100
0
6PM
9PM
7 Fri
3AM
6AM
9AM
12PM
3PM
6PM
6 Thu Feb 2014
Date of sample
Act : 2/6/2014 16:47:00
Act : 1.261 (kWh)
From : 2/6/2014 16:47:00
Maximum : 709.412 (kWh)
To : 2/7/2014 17:03:00
Minimum : 1.261 (kWh)


hvac oxy.STD (Energies (Tarif): Active + (Total))
kWh
400
350
300
250
200
150
100
50
0
6PM
9PM
8 Sat
3AM
6AM
9AM
12PM
3PM
6PM
7 Fri Feb 2014
Date of sample
Act : 2/7/2014 17:30:00
Act : 0.413 (kWh)
From : 2/7/2014 17:30:00
Maximum : 426.665 (kWh)
To : 2/8/2014 17:41:00
Minimum : 0.413 (kWh)


ware-house.STD (Energies (Tarif): Active + (Total))
kWh
12
10
8
6
4
2
0
12:05
12:10
12:15
12:20
12:25
12:30
12:35
22 Wed Jan 2014
Date of sample
Act : 1/22/2014 12:04:00
Act : 0.531 (kWh)
From : 1/22/2014 12:04:00
Maximum : 13.052 (kWh)
To : 1/22/2014 12:38:00
Minimum : 0.531 (kWh)


wip hvac.STD (Energies (Tarif): Active + (Total))
kWh
400
300
200
100
0
3PM
6PM
9PM
6 Thu
3AM
6AM
9AM
12PM
3PM
5 Wed Feb 2014
Date of sample
Act : 2/5/2014 15:14:00
Act : 0.331 (kWh)
From : 2/5/2014 15:14:00
Maximum : 464.120 (kWh)
To : 2/6/2014 15:54:00
Minimum : 0.331 (kWh)