Jurnal Teknologi

Full Paper

QUANTIFYING ENERGY SAVINGS FOR RETROFIT CENTRALIZED HVAC SYSTEMS AT SELANGOR STATE SECRETARY COMPLEX

Suhaidi Mohd Aris[a], Nofri Yenita Dahlan[a*], Mohd Nasrun Mohd Nawi[b], Tengku Ahmad Nizam[c], Mohamad Zamhari Tahir[b]

[a]Faculty of Electrical Engineering, Universiti Teknologi Mara Shah Alam (UiTM), Shah Alam, Selangor
[b]School of Technology Management & Logistics, Universiti Utara Malaysia, 06010 UUM Sintok, Malaysia
[c]M&V Energy Resources Sdn Bhd, Shah Alam, Selangor

Article history
Received
02 June 2015
Received in revised form
09 June 2015
Accepted
1 September 2015

*Corresponding author
nofriyenita012@ppinang.uitm.edu.my

Graphical abstract

Abstract

Objective of this study is to estimate building energy saving at Bangunan Sultan Salahuddin Abdul Aziz Shah from a retrofit of Water Cooling Package Unit (WCPU) system. This research calculates energy savings as recommended by International Performance Measurement and Verification Protocol (IPMVP) using Option C-Whole Facility Measurement. In this study, the baseline period is defined from July 2012 to June 2013, the retrofit of WCPU was performed on July 2013 and the reporting period is from August 2013 to July 2014. The baseline energy use and the post retrofit energy use data are collected from utility bills. On the other hand, the energy governing factors other than the retrofit such as outdoor temperature or Cooling Degree Day (CDD), number of working days (NWD) and occupancy on the building are gathered corresponding to the pre-defined baseline and post-retrofit period. These non-retrofit energy governing factors are used to model adjusted baseline energy in calculating energy savings using regression analysis. Two types of energy saving analyses have been presented in the case study; 1) Single linear regression for each independent variable, 2) Multiple linear regression. Results show that number of occupancy has the highest coefficient regression, R^2 followed by NWD and CDD. This indicates that occupancy has stronger correlation with the energy use in the building than NWD and CDD. Finding also shows that the R^2 for multiple linear regression model are higher than single linear regression model. This shows the fact that more than one component are affecting the energy use in the building.

Keywords: Component; IPMVP, regression analysis, number of working days (nwd), cooling degree days (cdd), number of occupancy, energy savings, energy cost avoidance.

1.0 INTRODUCTION

In Malaysia, various Energy Efficiency (EE) programmes have been conducted. These include Green Building Index (GBI), which was launched on 21st May 2009 to widen the usage of green technology green rating index on environment friendly buildings and the Ninth Malaysia Plan (2006-2010) to emphasise on initiatives and programmes to improve EE and promote the use of Renewable Energy (RE) in the buildings [1]. Public Work Department (PWD) and Malaysia Energy Commission (EC) aim to achieve 30% of energy savings on current 22,000 buildings through retrofitting works using Energy Performance Contract (EPC). However, currently there is no specific guideline or common practices being used by Energy Service Companies (ESCOs) and facility owners in measuring, computing and reporting energy savings in Malaysia.

There are several protocols that are being used worldwide for determining energy saving. One of the most common and widely used is the International Performance Measurement & Verification Protocol (IPMVP). The IPMVP presents a framework and defines terms used in determining saving after implementation of a project. There are four Measurement and Verification (M&V) options defined by the IPMVP i.e. 1) Option A – retrofit isolation with key parameter measurement, 2) Option B – retrofit isolation with all parameter measurement, 3) Option C – whole facility and 4) Option D – calibrated simulation. According to IPMVP, energy savings cannot be directly measured, since savings represent the absence of energy use. Instead, savings are determined by comparing measured energy use or demand before and after implementation of an Energy Conservation Measure (ECM). To properly report saving, the impact of ECM on the energy consumption must be separated from the impact of independent variables such as weather condition, working days, production and occupancy. The energy baseline before ECM is installed must be adjusted to the same conditions (independent variables) of the reporting period i.e. after the installation of ECM. This 'adjustment' distinguishes proper savings reports from a simple comparison of cost or usage before and after implementation of an ECM.

In Malaysia, the IPMVP is still a new concept for determining energy savings. Therefore, this paper presents a study to quantify energy savings from a retrofit work on Water Cooling Package Unit (WCPU) at Selangor State Secretary Complex using IPMVP. Three independent variables that affect electricity consumption in the building i.e. 1) Number of Working Days (NWD), 2) Cooling Degree Days (CDD) and 3) Occupancy are considered in the analysis. Effects of the independent variables on the electricity consumption are modelled using single and multiple regression analysis. The energy savings are calculated using energy avoidance approach.

2.0 SELANGOR STATE SECRETARY COMPLEX

The study was performed on Selangor State Secretary office complex, an iconic landmark which is located at Shah Alam, Selangor. Sultan Salahuddin Abdul Aziz Shah (SSAAS) building in Shah Alam was built in 1977. The construction was made in two stages. The first stage was the North Podium and the second stage covered South Podium and Tower. The total area of the entire building is 578,250 square meters. The North podium was completed and in use since 1st January 1981.The selected building is a typical twenty five storey office building which contains assignable of instructional space including office spaces, lobby, meeting rooms and cafe. In total there are 56 departments in this building.

Figure 1 Selangor state secretary complex satellite view.

The existing office buildings in Malaysia may have inefficient electrical energy usage and poor energy optimization consumption due to the following reasons; high energy consumption equipment is in place, internal power losses unanticipated such as poor power factor and energy conservation program has not engaged. As a result of that, high electricity bill is observed due to unwanted power losses in the building system which can cause high operation cost for the commercial buildings expenditure. This is also happening at Selangor State Secretary Complex. As an effort to reduce the energy consumption in the building, some retrofitting programs have been implemented such as upgrading the Water Cooling Package Unit (WCPU) system in July 2013. The upgrading work includes changed of 2 set of Air Handling Unit (AHU) and upgrading the air ventilation ducting. Figure 2 shows the HVAC system for Selangor State Secretary Complex.

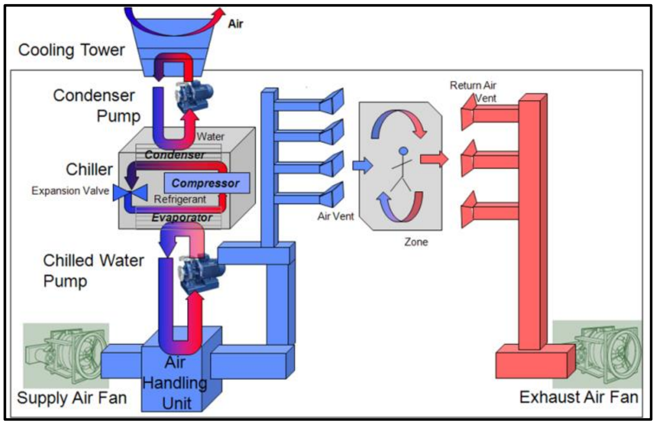

Figure 2 Selangor state secretary complex HVAC systems

2.1 Energy Avoidance

In calculating energy avoidance, energy baseline is first developed using mathematical model which correlates actual baseline energy with independent variables. In this paper, the mathematical models are developed using single and multiple linear regression for each independent variable i.e. NWD, CDD and Occupancy. Then, each reporting period's independent variables are inserted into the baseline equation to calculate the adjusted baseline energy. The energy cost avoidance is the difference between the adjusted baseline energy and reporting energy with respect to the reporting period condition.

$$Savings = (Baseline\ Energy - Reporting\ Period\ Energy) \pm Routine\ Adjustment \pm Non\ Routine\ Adjustments \quad (1)$$

2.2 Independent Variables

Characteristics of a facility use or environment which governs the energy consumption are called independent variables. Common independent variables are weather, number of working days and occupancy. Weather has many dimensions, but for whole building analysis weather is most often just outdoor temperature and possibly humidity depending upon the climate of the facility. Occupancy may be defined in many ways, such as office building core occupancy hours or maximum hours, number of occupied days (weekdays/weekends) and total visitors. To the extent that independent variables have a cyclical nature to them, the significance of their impact on energy use can be assessed through mathematical modelling. Parameters found to have a significant effect in the base year period should be included in the routine adjustments.

Independent variables should be measured and recorded at the same time as the energy meters. For example, weather data should be recorded daily so it can be totalled to correspond with the exact monthly energy metering period which may be different from the calendar month. Monthly mean temperature data for a non-calendar month would introduce unnecessary error into the model.

2.3 Reporting Savings Considering Errors in Modelling Baseline using Regression.

Energy savings should be reported together with its relative precision at a given confidence level. Errors in reporting savings can come from; 1) metering which arises from the accuracy of sensors, calibration and etc., 2) sampling which arises when only a portion of the actual values is measured and 3) mathematical modeling error. In this paper, the error considers is only from modeling baseline using regression. Standard Error (SE) of the baseline can be presented in Equation (2) below;

$$\text{Standard Error (SE)}_{\text{monthly}} = \sqrt{\frac{\Sigma(\text{Yi}' - \text{Yi})^2}{n - p - 1}} \quad \textbf{(2)}$$

where $Yi'$is the model predicted energy value, Yi is the actual energy value, *n* is sample size and *p* is number of regression model variable.

Since the baseline model is used to calculate the adjusted baseline for one year i.e. 12 months, therefore the combined standard error for the 12 months must be calculated as shown in Equation (3).

$$Standard\ Error_{\ (annually)} = \sqrt{12}\ x\ SE_{(monthly)} \quad (3)$$

Absolute precision of the annual savings is calculated using Equation (4) below;

$$Absolute\ Precision = \text{t x } SE_{(annually)} \quad (4)$$

where *t* is the t-value in the T-table for a given 12 sample size and at specific pre-defined confidence level.

The relative precision is given by the Equation (5) below;

$$Relative\ Precision = \frac{Absolute\ Precision}{Annual\ Energy\ Avoided} \quad (5)$$

2.4 Test Data

The energy consumptions data for the baseline and reporting period are gathered from July 2012 to Jun 2013 and August 2013 to July 2014 respectively. These energy consumption data are gathered from monthly utility bill. Three independent variables have been considered are the number of working days, weather and building occupancy to determine the energy saving. The number of working days is referred to working calendar in the state of Selangor. The weather data is gather from the nearest weather station i.e. Subang/Sultan Abdul Aziz Shah Airport, MY (101.55E,3.13N). This should give a better representation of the weather at the building than any "reference" station for the larger region in which the building sits. There are two type of occupancy in this building, i.e. 1) full time employees and 2) visitors. The full time employees' occupancy data is collected from attendance record, meanwhile the visitors' occupancy data is gathered from the registration at the guard house. For the visitors' occupancy, it is assumed that each visitor in average spent one hour in the building to complete their individual business. Therefore, eight number of visitor equivalent to one fulltime staff that spent 8 hours of their time in the building. The number of occupancy in a month is the sum of the total fulltime staff and the equivalent visitor-fulltime staff in the building.

3.0 RESULT AND DISCUSSION

3.1 Single Linear Regression for Number of Working Days.

Table 1 below shows the baseline data for NWD and energy consumption that are used to model baseline equation using single regression analysis.

Table 1 No. of working days baseline data from July 2012 to Jun 2013

BASELINE DATA		
MONTH	NO OF WORKING DAYS	CONSUMPTONS (KWh)
JULY 2012	22	1,069,780.00
OGOS 2012	19	854,014.00
SEPT 2012	19	978,477.00
OCT 2012	22	1,041,784.00
NOV 2012	20	1,020,500.00
DEC 2012	19	941,609.00
JAN 2013	20	975,809.00
FEB 2013	18	861,164.00
MAC 2013	21	1,093,194.00
APR 2013	22	1,116,855.00
MEI 2013	21	1,016,000.00
JUN 2013	20	1,085,731.00

From the regression analysis, the coefficient of determination, R^2 for NWD is **0.6733** and the baseline linear equation is $\boldsymbol{y = 52142x_1 - 51298}$ where x_1 is the NWD and y is the energy use. This is shown in Fig 3.

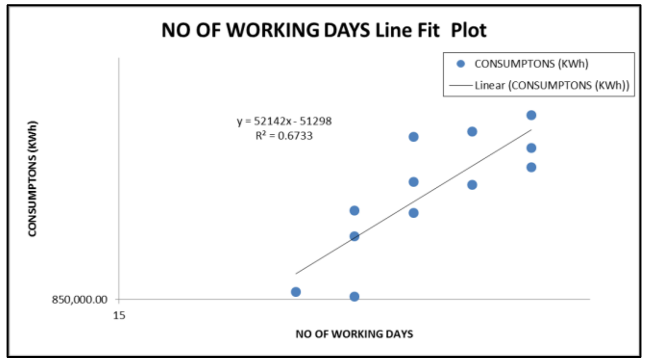

Figure 3 Single linear regression for no. of working days.

The baseline energy is adjusted to the same set condition of the reporting period by plugging the NWD values of the reporting period in the linear equation above. Energy avoidance is determined by comparing the adjusted baseline energy and measured energy during reporting period which is equal to 462,326 kWh as shown in Table 2. The graph in Figure 4 shows the difference between baseline, adjusted baseline and reporting period consumption for NWD.

Table 2 No of working days reporting period & energy saving data from August 2013 to July 2014

POST-RETROFIT DATA			ADJUSTED BASELINE DATA			
MONTH	NO OF WORKING DAYS	CONSUMPTONS (KWh)	FACTORS SENSITIVITY 52142x	FACTORS BASELOAD 51298	ADJUSTED CONSUMPTIONS (KWh)	ENERGY AVOIDED
OGOS 2013	20	936,733.00	1042840	51298	991542.00	54809.00
SEPT 2013	20	1,014,639.00	1042840	51298	991542.00	-23097.00
OCT 2013	22	1,048,911.00	1147124	51298	1095826.00	46915.00
NOV 2013	21	1,023,801.00	1094982	51298	1043684.00	19883.00
DEC 2013	20	975,893.00	1042840	51298	991542.00	15649.00
JAN 2014	19	863,132.00	990698	51298	939400.00	76268.00
FEB 2014	20	901,924.00	1042840	51298	991542.00	89618.00
MAC 2014	21	1,013,198.00	1094982	51298	1043684.00	30486.00
APR 2014	22	1,083,790.00	1147124	51298	1095826.00	12036.00
MEI 2014	20	984,581.00	1042840	51298	991542.00	6961.00
JUN 2014	21	1,035,255.00	1094982	51298	1043684.00	8429.00
JULY 2014	20	867,173.00	1042840	51298	991542.00	124369.00
		11,749,030.00			12211356.00	462326.00

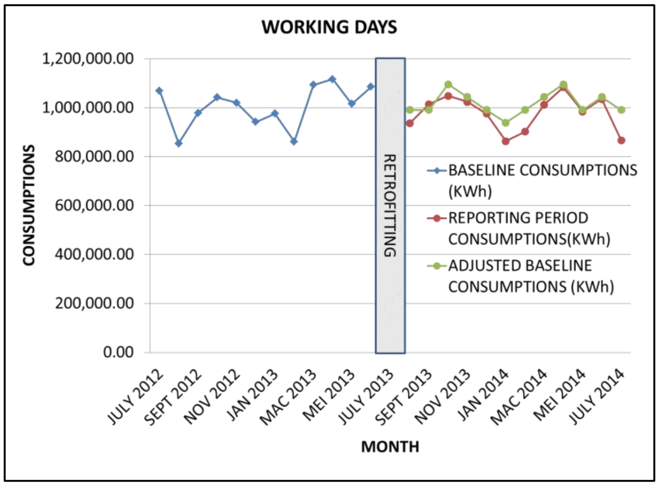

Figure 4 Graph comparison baseline, reporting period and adjusted consumptions for single linear no. of working days

The monthly standard error from the baseline equation is 51,691.40 kWh. The annual standard error is 179,064.28 kWh. From the T-table, the t-value for 12 months sample size and 1 variable at 95% Confidence Level is 2.23. Therefore, the absolute precision is calculated as 399,313.39 kWh and the relative precision is 86.37%. The estimated annual savings considering NWD can be expressed as 462,326 kWh ± 86.37% at confidence level of 95%.

3.2 Single Linear Regression for Cooling Degree Days

Table 3 shows the baseline data for Cooling Degree Days (CDD) and energy consumption that are used to model baseline equation using single regression analysis.

Table 3 Cooling degree baseline data from July 2012 to Jun 2013

BASELINE DATA		
MONTH	COOLING DEGREE DAYS (CDD)	CONSUMPTONS (KWh)
JULY 2012	577	1,069,780.00
OGOS 2012	582	854,014.00
SEPT 2012	557	978,477.00
OCT 2012	573	1,041,784.00
NOV 2012	543	1,020,500.00
DEC 2012	525	941,609.00
JAN 2013	562	975,809.00
FEB 2013	481	861,164.00
MAC 2013	615	1,093,194.00
APR 2013	588	1,116,855.00
MEI 2013	616	1,016,000.00
JUN 2013	619	1,085,731.00

From the regression analysis, the coefficient of determination, R^2 for CDD is **0.4255** and the baseline linear equation is $\boldsymbol{y = 1391.3x_2 + 211788}$ where x_2 is the CDD and y is the energy use. This is shown in Fig 5.

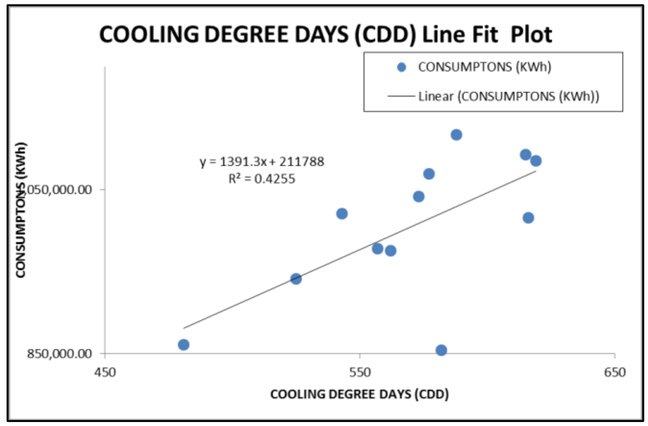

Figure 5 Single linear regression for cooling degree days.

Total energy avoidance during the reporting period considering CDD is equal to **228,222.60 kWh** as shown in Table 4. The graph in Figure 6 shows the baseline, adjusted baseline and reporting period consumptions with CDD as independent variable.

Table 4 Cooling degree days reporting period & energy saving data from August 2013 to July 2014

POST-RETROFIT DATA			ADJUSTED BASELINE DATA			
MONTH	COOLING DEGREE DAYS (CDD)	CONSUMPTONS (KWh)	FACTORS		ADJUSTED CONSUMPTIONS (KWh)	ENERGY AVOIDED
			SENSITIVITY	BASELOAD		
			1391.3.6x	211788		
OGOS 2013	572	936,733.00	795823.6	211788	1007611.60	70878.60
SEPT 2013	526	1,014,639.00	731823.8	211788	943611.80	-71027.20
OCT 2013	554	1,048,911.00	770780.2	211788	982568.20	-66342.80
NOV 2013	519	1,023,801.00	722084.7	211788	933872.70	-89928.30
DEC 2013	529	975,893.00	735997.7	211788	947785.70	-28107.30
JAN 2014	492	863,132.00	684519.6	211788	896307.60	33175.60
FEB 2014	546	901,924.00	759649.8	211788	971437.80	69513.80
MAC 2014	621	1,013,198.00	863997.3	211788	1075785.30	62587.30
APR 2014	560	1,083,790.00	779128	211788	990916.00	-92874.00
MEI 2014	591	984,581.00	822258.3	211788	1034046.30	49465.30
JUN 2014	641	1,035,255.00	891823.3	211788	1103611.30	68356.30
JULY 2014	631	867,173.00	877910.3	211788	1089698.30	222525.30
		11,749,030.00			11977252.60	228222.60

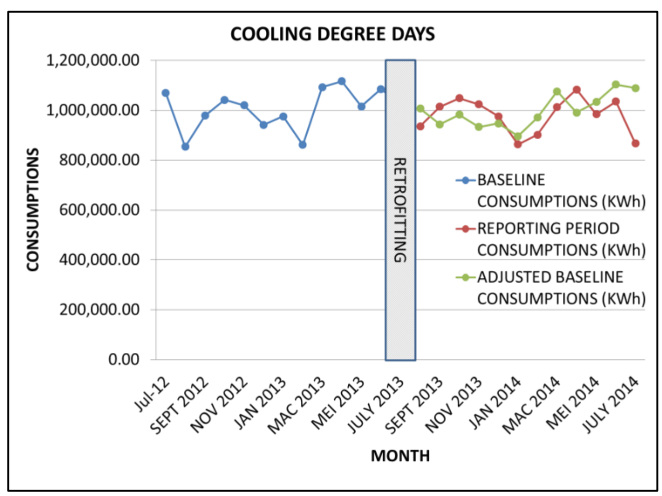

Figure 6 Graph comparison baseline, reporting period and adjusted consumptions for single linear cooling degree days.

In this case of CDD, the monthly standard error from the baseline equation is 68,542.99 kWh. The annual standard error is 237,439.9 kWh. From T-table, the t-value for 12 months sample size and 1 variable at 95% Confidence Level is 2.23. Therefore, the absolute precision is calculated as 529,490.9 kWh and the relative precision is 232%. The estimated annual savings considering CDD can be expressed as 228,222.6 kWh ± 232% at confidence level of 95%.

3.3 Single Linear Regression for Occupancy

Table 5 shows the baseline data for occupancy and energy consumption that are used to model baseline equation using single regression analysis.

Table 5 Occupancy baseline data from July 2012 to Jun 2013

BASELINE DATA		
MONTH	OCCUPANCY	CONSUMPTONS (KWh)
JULY 2012	43121	1,069,780.00
OGOS 2012	35314	854,014.00
SEPT 2012	37833.88	978,477.00
OCT 2012	43612	1,041,784.00
NOV 2012	38201.88	1,020,500.00
DEC 2012	33443.4	941,609.00
JAN 2013	35375	975,809.00
FEB 2013	33178	861,164.00
MAC 2013	40710	1,093,194.00
APR 2013	42444	1,116,855.00
MEI 2013	40078	1,016,000.00
JUN 2013	38689	1,085,731.00

From the regression analysis, the coefficient of determination, R^2 for No. of Working Days is **0.6752** and the linear equation is $\boldsymbol{y = 19.527x_3 + 252,774}$ where x_3 is the occupancy and y is the energy use. This is shown in Fig 7.

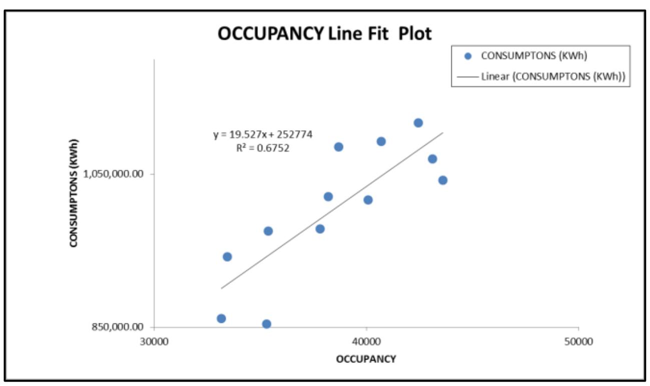

Figure 7 Single linear regression for occupancy.

Total energy avoidance during the reporting period considering number of occupancy is equal to **284,018.95 kWh** as shown in Table 6. The graph in Figure 8 shows the difference between baseline, adjusted baseline and reporting period consumptions with number of occupancy.

Table 6 Occupancy reporting period & energy saving data from August 2013 to July 2014

POST-RETROFIT DATA			ADJUSTED BASELINE DATA			
MONTH	OCCUPANCY	CONSUMPTONS (KWh)	FACTORS		ADJUSTED CONSUMPTIONS (KWh)	ENERGY AVOIDED
			SENSITIVITY	BASELOAD		
			19.527x	252774		
OGOS 2013	36662	936,733.00	715898.874	252774	968672.87	31939.87
SEPT 2013	37978.25	1,014,639.00	741601.288	252774	994375.29	-20263.71
OCT 2013	41105	1,048,911.00	802657.335	252774	1055431.34	6520.33
NOV 2013	40776	1,023,801.00	796232.952	252774	1049006.95	25205.95
DEC 2013	33180.3	975,893.00	647911.718	252774	900685.72	-75207.28
JAN 2014	33755	863,132.00	659133.885	252774	911907.89	48775.89
FEB 2014	38718	901,924.00	756046.386	252774	1008820.39	106896.39
MAC 2014	40616	1,013,198.00	793108.632	252774	1045882.63	32684.63
APR 2014	43139	1,083,790.00	842375.253	252774	1095149.25	11359.25
MEI 2014	37615.5	984,581.00	734517.869	252774	987291.87	2710.87
JUN 2014	40654	1,035,255.00	793850.658	252774	1046624.66	11369.66
JULY 2014	36689	867,173.00	716426.103	252774	969200.10	102027.10
		11,749,030.00			12033048.95	284018.95

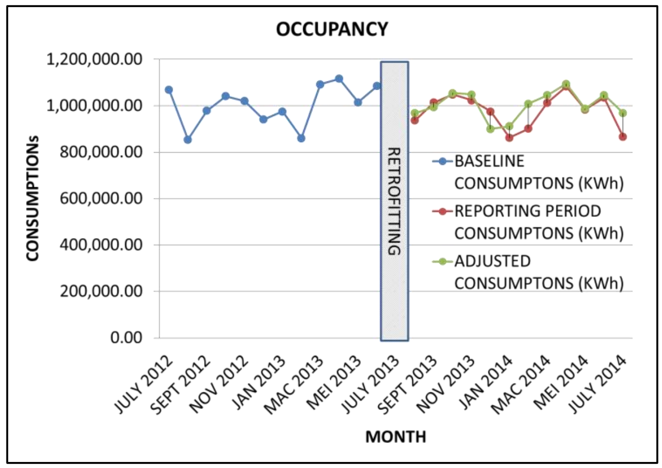

Figure 8 Graph comparison baseline, reporting period and adjusted consumptions for single linear occupancy.

In this case of occupancy, the monthly standard error from the baseline equation is 51,539.81 kWh. The annual standard error is 178,539.15 kWh. From T-table, the t-value for 12 months sample size and 1 variable at 95% Confidence Level is 2.23. Therefore, the absolute precision is calculated as 398,142.3 kWh and the relative precision is 140%. The estimated annual savings considering CDD can be expressed as 284,018.95 kWh ± 140% at confidence level of 95%.

3.4 Multiple Linear Regression for the Considered Independent Variables.

Multiple regression is an extension of linear regression which consists of several independent variables. In this case, three independent variables i.e. NWD, CDD and occupancy are considered at the same time while modeling the baseline equation.

Table 7 shows the baseline data for NWD, CDD, occupancy and energy consumption that are used to model baseline equation using multiple regression analysis.

Table 7 TaMultiple baseline data from July 2012 to Jun 2013

BASELINE DATA				
MONTH	NO OF WORKING DAYS	Cooling Degree Days (CDD)	Occupancy	CONSUMPTONS (KWh)
JULY 2012	22	577	43121	1,069,780.00
OGOS 2012	19	582	35314	854,014.00
SEPT 2012	19	557	37833.88	978,477.00
OCT 2012	22	573	43612	1,041,784.00
NOV 2012	20	543	38201.88	1,020,500.00
DEC 2012	19	525	33443.4	941,609.00
JAN 2013	20	562	35375	975,809.00
FEB 2013	18	481	33178	861,164.00
MAC 2013	21	615	40710	1,093,194.00
APR 2013	22	588	42444	1,116,855.00
MEI 2013	21	616	40078	1,016,000.00
JUN 2013	20	619	38689	1,085,731.00

From the multiple regression, the multiple linear equation obtained is $\boldsymbol{y = 22,823.225x_1 + 445.884x_2 + 8.422x_3 - 37625.068}$ where x_1 is NWD, x_2 is CDD and x_3 is occupancy. The coefficient of determination, R^2 of this multiple regression case is 0.7232, which higher than the single regression cases.

Total energy avoidance during the reporting period for the multi regression case is equal to 339,912.98 kWh as shown in Table 8. The graph in Figure 9 shows the difference between baseline, adjusted baseline and reporting period consumptions with multiple independent variables.

In this case of multiple variables, the monthly standard error from the baseline equation is 53,196.21 kWh. The annual standard error is 184,277.07 kWh. From T-table, the t-value for 12 months sample size and 3 variables at 95% Confidence Level is 2.31. Therefore, the absolute precision is calculated as 425,680.03 kWh and the relative precision is 125%. The estimated annual savings considering CDD can be expressed as 339,912.98 kWh ± 125% at confidence level of 95%.

Table 8 Multiple baseline data from July 2012 to Jun 2013

POST-RETROFIT DATA					ADJUSTED BASELINE DATA					
MONTH	NO OF WORKING DAYS	Cooling Degree Days (CDD)	OCCUPANCY	CONSUMPTONS (KWh)	FACTORS: NO OF WORKING DAYS SENSITIVITY	COOLING DEGREE DAYS SENSITIVITY	OCCUPANCY SENSITIVITY	INTERCEPT	ADJUSTED CONSUMPTIONS (KWh)	ENERGY AVOIDED
					$22823.225x^1$	$448.884x^2$	$8.422x^3$	-37625.068		
OGOS 2013	20	572	36662	936,733.00	456464.5	256761.648	308767.364	-37625.068	984368.44	47635.4
SEPT 2013	20	526	37978.25	1,014,639.00	456464.5	236112.984	319852.8215	-37625.068	974805.24	-39833.7
OCT 2013	22	554	41105	1,048,911.00	502110.95	248681.736	346186.31	-37625.068	1059353.93	10442.9
NOV 2013	21	519	40776	1,023,801.00	479287.725	232970.796	343415.472	-37625.068	1018048.93	-5752.0
DEC 2013	20	529	33180.3	975,893.00	456464.5	237459.636	279444.4866	-37625.068	935743.55	-40149.4
JAN 2014	19	492	33755	863,132.00	433641.275	220850.928	284284.61	-37625.068	901151.75	38019.7
FEB 2014	20	546	38718	901,924.00	456464.5	245090.664	326082.996	-37625.068	990013.09	88089.0
MAC 2014	21	621	40616	1,013,198.00	479287.725	278756.964	342067.952	-37625.068	1062487.57	49289.5
APR 2014	22	560	43139	1,083,790.00	502110.95	251375.04	363316.658	-37625.068	1079177.58	-4612.4
MEI 2014	20	591	37615.5	984,581.00	456464.5	265290.444	316797.741	-37625.068	1000927.62	16346.6
JUN 2014	21	641	40654	1,035,255.00	479287.725	287734.644	342387.988	-37625.068	1071785.29	36530.2
JULY 2014	20	631	36689	867,173.00	456464.5	283245.804	308994.758	-37625.068	1011079.99	143906.9
				11,749,030.00					12088942.98	339912.9

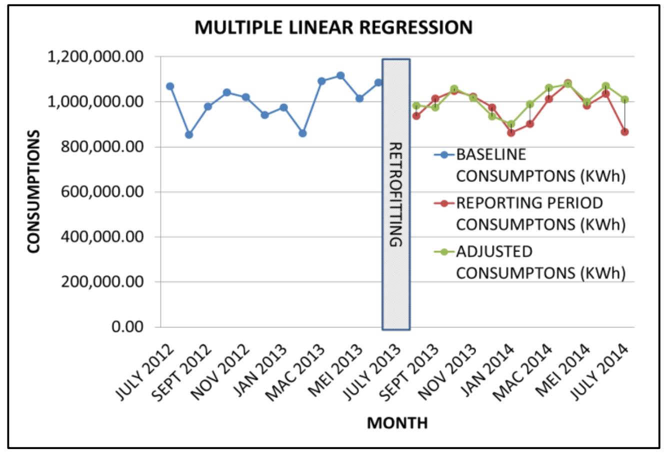

Figure 9 Graph comparison baseline, reporting period and adjusted consumptions for multiple linear.

4.0 CONCLUSION

This study is conducted to determine the energy saving in SSAAS buildings after upgrading the WCPU considering various independent variables i.e. NWD, CDD and occupancy. The energy saving analyses are performed using single and multiple linear regression. Results show that the single linear regression coefficient R^2 for NWD is 0.6733, coefficient R^2 for CDD is 0.4255 and coefficient R^2 for occupancy is 0.6752. On the other hand, combining the variables using multiple linear regression provides coefficient R^2 of 0.7232. This shows that occupancy has the strongest correlation with energy use followed by NWD and then CDD. Since multiple regression gives higher coefficient regression than single linear regression, this shows that more than one factors affacting the energy use in the building. Higher standard errors are shown in all the analyses. There are several recommendation highlighted by IPMVP to reduce this standard error such as: 1) take more precise measurement equipment, 2) consider more independent variables in the mathematical model, 3) take a larger sample size, or 4) choose M&V Option that is less affected by unknown variables.

Acknowledgement

Profound appreciation to all departments in the Sultan Salahuddin Abdul Aziz Shah Building, Shah Alam for providing all the data that are needed for conducting the study.

References

[1] Ninth Malaysia Plan. 2006. Ninth Malaysia Plan 2006-2010. Published By The Economic Planning Unit, Prime Minister's Department, Putrajaya, Malaysia. http://www.epu.jpm.my

[2] S. Moghimi, et al. 2011. "Building Energy Index (BEI) In Large Scale Hospital: Case Study Of Malaysia," Presented At The *Proceedings Of The 4th WSEAS International Conference On Energy And Development - Environment - Biomedicine*, Corfu Island, Greece

[3] A. Z. Ahmed. 2009. Professorial Lecture "*Climate Change, Green Technology and Sustainable Buildings*". Shah Alam: University Publication Center (UPENA) UiTM

[4] C. W. Wai, et al. 2011."Energy Management Key Practices: A Proposed List for Malaysian Universites. *International Journal of Energy and Environment.* 2: 749-760,

[5] N. S. Yen, et al. 2010. "Energy Conservation Opportunities in Malaysian Universities," *Malaysian Journal of Real Estate*. 5

[6] N. S. Yen and C. W. Wai. 2010. The Needs to Measure Energy Awareness in Malaysian Universities, in *International Universities Social Responsibility Conference and Exhibition 2010*, Kuala Lumpur,

[7] T. H. d. A. Kementerian Tenaga. (2006, 15/12/2011). The Utility Industries: Shaping The Future. Available: http://www.kettha.gov.my/node/1008

[8] J. C. Van Gorp. 2004. Maximizing Energy Savings With Enterprise Energy Management Systems. in *Pulp and Paper Industry Technical Conference, 2004*. *Conference Record of the 2004 Annual*. 175-181.