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Saving Quantification for Electrical Energy Management Program Considering Integration of Net Energy Metering Scheme

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ABSTRACT

Retrofitting an efficient chillers system is one of the Energy Conservation Measures (ECM) under the Energy Efficiency (EE) program. Meanwhile, installing a PV system for electricity generation could be considered a different approach under Renewable Energy (RE) program. However, it might be challenging to determine the actual electrical energy savings when various factors are other before and after EE & RE program implementation concurrently. Therefore, those conditions will affect the quantification of genuine savings. Due to that reason, the Measurement and Verification (M&V) approach is introduced to validate the actual savings of the retrofit program. Thus, this study proposes an approach considering the routine and non-routine adjustment of the baseline where the regression analysis determination was used to identify the correlation level of the significant variables. Furthermore, by considering the static component in the M&V method, the electricity pricing from Net Energy Metering (NEM) scheme has been adopted congruently as the validation process of the RE solution. Therefore, option B has been used to establish the energy savings of the new chiller retrofit program. In contrast, Option C was applied to quantify the entire energy savings of the building after the NEM scheme had been incorporated. Consequently, the conventional energy saving percentage and the integrated energy performance under the NEM scheme have been determined concurrently. As a result, the solution can compute approximately 10.65% electrical energy saving annually, considered an actual saving declaration for the integrated EE and RE program in a building.

Keywords:
Energy efficiency; Energy conservation; Measurement and verification; Solar PV; Net energy metering

1. Introduction

The building sector has experienced increased energy consumption in recent years due to rising living standards and growing demand for thermal comfort and indoor air quality. Enhancing the

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energy performance of the built environment has become a top priority worldwide to address this growing energy consumption [1]. One of the most effective and economical approaches to improving the energy performance of existing buildings is implementing suitable retrofit strategies. As adopting retrofit strategies becomes more widespread, the importance of the M&V method cannot be overstated to determine the actual energy savings and evaluate the impact of the investment [2]. This is particularly important if they enter into an Energy Performance Contract (EPC) with an Energy Services Company (ESCO), an increasingly popular option [3]. Moreover, ESCOs, which guarantee energy reduction, face potential financial penalties if they do not deliver on their promises. Measurement and verification (M&V) approaches for energy savings are based on five fundamental principles: accuracy, completeness, conservatism, consistency and transparency [4]. Widely recognized and established M&V methodologies include the International Performance Measurement and Verification Protocol (IPMVP), the American Society of Heating, Refrigerating, and Air-conditioning Engineers (ASHRAE) Guideline, and ISO 50015-2014. The IPMVP categorizes M&V procedures into four options (A to D) [5,6] By adhering to these M&V guidelines and selecting the appropriate option, building owners, investors, and ESCOs can establish a robust and reliable method to evaluate the effectiveness of energy-saving measures. By implementing the best practices in M&V, energy management efforts are directly supported, as the impact of implemented energy conservation measures (ECMs) on energy consumption and costs can be assessed by decision-makers. This approach ultimately contributes to more effective energy management strategies.

Energy management strategies are essential for maximizing energy efficiency solutions in commercial and industrial facilities. A comprehensive approach can help organizations reduce energy consumption, minimize costs, and decrease environmental impact. Among the strategies are Implementing Energy Conservation Measures (ECMs), such as upgrading lighting systems, improving HVAC controls, and optimizing building automation systems, which can increase energy efficiency and reduce energy waste. One practical example is commercial buildings with centralized cooling systems. In such cases, poor performance due to the ageing of the current chiller system is a general factor affecting the inefficiency of energy consumption [7]. This condition will lead to rising energy waste and inefficient energy utilization. The chiller system is one of the largest consumers of energy in a building [8]. Replacing current chillers with new high-efficiency chillers would dramatically reduce electricity consumption and electrical demand [9]. In addition to energy efficiency (EE) solutions, renewable energy (RE) methods can also benefit the operational costs of a building. However, many people remain unaware of the importance of RE in reducing energy costs. Malaysia, a country with abundant sunshine, offers great potential for power generation from solar photovoltaic (PV) systems. Despite this potential, Malaysia's PV generation only accounts for about 0.2% of total power generation, with a total installed capacity of 168 MW in 2014, far from the national target of 1 GW by 2020 [10]. To address this underutilization of solar power, Malaysia introduced enhancements to the Net Energy Metering (NEM) program in 2019. This program permits excess solar PV-generated energy to be exported back to the grid, enabling a one-to-one offset basis for energy credits.

This study analyses the savings from EE and RE programs where the M&V method has been adopted and implemented. Previous literature has discussed the correlation between multiple variables in implementing M&V to quantify actual savings. Examples include single and multiple regression analyses for general management purposes [11], for hospitals [12], assessing the correlation of variables affecting energy consumption during the pandemic [13], discussing uncertainty regression analysis of energy usage [14], and examining the regression test of variables in complex saving quantification for buildings [17]. Forecasting and optimization algorithms, such as artificial neural networks (ANN) [18], hybrid ANN models for baseline establishment [15], and hybridization algorithms [16,17] have also been used to quantify savings involving uncertain conditions. However, these studies typically focus on a single EE solution rather than EE and RE solutions in quantifying actual savings under the M&V method. To the best of our knowledge, limited research serves as guidance for considering the quantification of savings for both EE and RE solutions simultaneously. Therefore, this study has investigated the appropriate method for energy-saving determination for the new retrofit chillers system and the proposal of the solar PV installation under the NEM scheme concurrently. Thus, the contribution of this paper can be described as follows:

i. Establishing a method to investigate the energy waste and energy savings for the chiller retrofit in a building.
ii. Finding the baseline adjustment of the significant variables that will be considered in counting energy saving under the M&V protocol.
iii. Enhancing energy cost mitigation performance after retrofitting the chiller by simulating the NEM scheme.

The paper has been arranged as follows: Section 2 presents the related review under the related study, while Section 3 presents the study's methodology. Section 4 discusses the results, and Section 5 concludes the study’s findings.

2. Measurement & Verification (M&V)

According to Carstens, Xia, and Yadavalli [18], Measurement and Verification (M&V) is a field that quantifies the savings achieved through energy efficiency, demand response, and demand-side management programs using measurements and energy models. The process typically starts with measuring or sampling a population to establish a baseline, followed by an intervention. Implementing M&V in energy savings projects has recently gained significant attention due to regulations imposed by global energy policies [19]. The M&V approach is crucial as it measures the savings generated by an energy-saving strategy and optimizes energy savings [20,21]. The essential principle of the IMPVP in reporting energy savings is accurate, complete, consistent, relevance, and transparent. The IPMVP provides four measurement options to evaluate the savings [22] according to their area of applicability: Option A, B, C and D.

i. Option A: Key Parameter Measurement Retrofit Isolation. To determine the energy savings at the retrofit point, at least one parameter must be measured, and others can be estimated using the building's history or the manufacturer's specifications.
ii. Option B: All Parameter Measurements Retrofit Isolation, where all parameters must be measured.
iii. Option C: Whole Facility. Where energy consumption for the entire or sub-facility must be determined to determine energy savings.
iv. Option D: Calibrated Simulation using energy simulation software. Additionally, two related concepts are vital to understanding the fundamentals of M&V: baseline adjustment and Energy Conservation Measures (ECM). The details of these concepts are provided below:

2.1 Baseline Adjustment

Baseline adjustment in M&V refers to determining a reference point for energy consumption before implementing an energy conservation measure (ECM). This reference point allows for comparing energy usage before and after the intervention. There are TWO (2) types of baseline adjustment; Routine adjustment and non-routine adjustment. Routine adjustment is energy use may be routinely adjusted based on independent variables such as weather, occupancy, ambient temperature, and business hours. Meanwhile, non-routine adjustment is energy use that may be non-routinely adjusted based on a static factor such as building size, design, installed equipment operation, and occupant type. Non-routine adjustments in the measurement and verification (M&V) context cause changes in building energy consumption that are not attributed to installed efficiency measures or accounted for in the baseline model's independent variables [23]. Thus, Figure 1 shows the estimate saving illustration comparison of the baseline and reporting periods where the adjustment baseline has been considered.

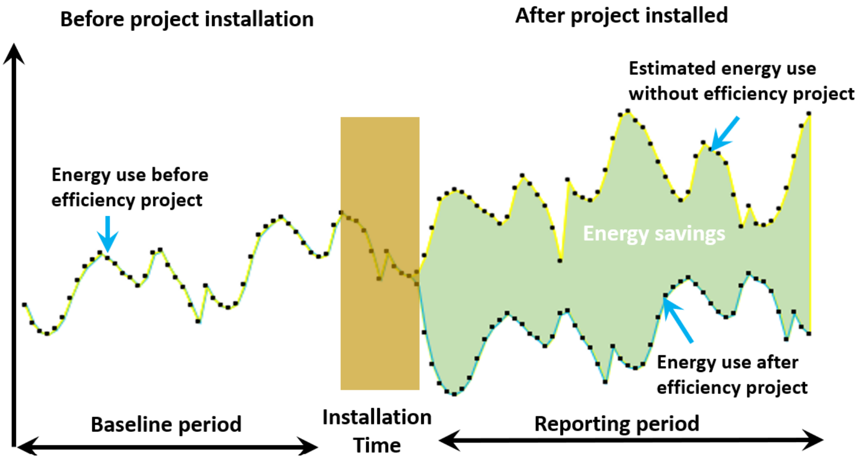


Fig. 1. Estimated savings after the installation of the ECM diagram [24]

2.2 Energy Conservation Measures (ECMs)

Regarding system operations, buildings are a primary target for energy conservation since they are frequently known to be inefficient. Many buildings have been built without considering the proper selection of construction materials, air conditioning for each piece of equipment, appliances, lighting, and control systems targeted at boosting thermal comfort and energy efficiency [25]. Thus, Figure 2 shows the general load apportioning in a commercial building where the consideration of Energy Conservation Measures (ECMs) will strategically be focused. Energy Conservation Measures (ECMs) are any technical strategies that enhance a building's energy efficiency [26]. These measures aim to improve a building's energy performance through various approaches, such as increased energy efficiency, reduced operating hours, and integration of renewable energy sources [27]. The building industry faces the critical challenge of significantly reducing energy consumption, which can be effectively addressed through appropriate ECMs. To decrease energy use in buildings, cost-effective energy retrofit solutions involving the implementation of ECMs are essential [28]. However, demonstrating the effectiveness of a particular ECM can be challenging due to the numerous factors that impact a building's energy consumption before and after its implementation [29].

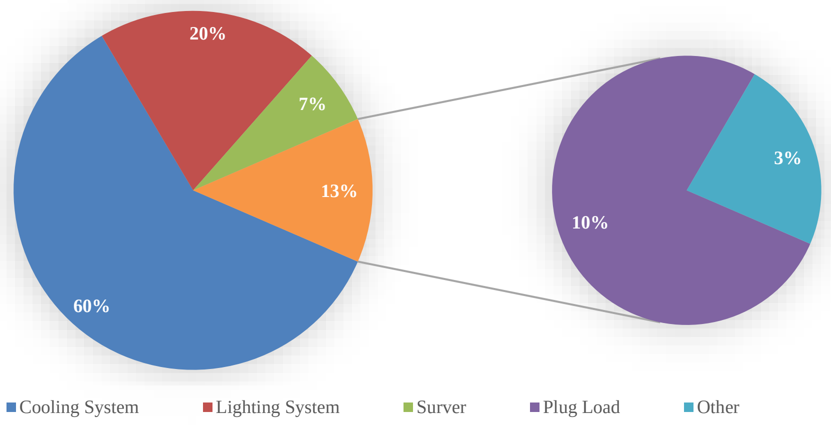


Fig. 2. Load breakdown for the general commercial buildings for energy efficiency program energy measures action

3. Methodology

In this study, Option B and Option C have been focused. Through Option B, savings are determined by field measurement of the energy use to which the ECM is applied, separate from the energy use of the rest of the facility. All the key parameter measurements are measured without estimated values. The baseline adjustment of significant variables is analysed using regression analysis to obtain the exact variable that affects the energy consumption in the management building of a higher educational institute. The Net Energy Metering (NEM) Scheme was then stimulated to enhance the performance of the energy cost mitigation after retrofitting the chiller. NEM allows excess solar PV-generated energy to be exported back to the grid on a directional offset basis. Three different amounts of solar installation are applied in this study, 100kWp installation, 200kWp installation, and 300kWp installation. Finally, the performance of energy cost mitigation was later observed and investigated after stimulating the NEM program. Consequently, the study flow is determined by Table 1, while the rest of the detail's method will be explained in sub-section 3.1 until 3.4 accordingly.

Table 1
The flow of the study to determine actual savings from retrofitting projects and the NEM Scheme

START
Step 1: Collect chiller energy consumptions data for pre-retrofit and post-retrofit Step 2: Analyse pre-retrofit and post-retrofit data of the chiller by using regression analysis. (Option B Step 3: Collect building energy consumptions before NEM implementation (Option C) Step 4: Simulate NEM program: proposes Solar PV installation capacity. Step 5: Get output from NEM implementation. (If Yes, then proceed to analyse the result in Step 6; if No, go back to simulate the NEM Scheme (Step 4) Step 6: Analysis of the results of building energy after NEM implementation Step 7: Declare Actual Saving *END*

3.1 Energy Conservation Measures (ECMs)

In this study, the investigation has been made into the chiller retrofitting project, which is upgrading to energy efficient chillers. Thus, energy avoidance is calculated by using the equation:

$$Energy\ savings = (AC - RC) \pm AP \tag{1}$$

AC, RC, and AP are the adjusted consumption, reporting consumption, and absolute precision. The adjusted consumption can be modelled with single linear and multiple regression models. Meanwhile, the electricity cost reduction differs between energy consumption after retrofit and baseline energy consumption before retrofit, as described in Eq. (2).

$$\text{ECR=Epost - Epre} \tag{2}$$

Where ECR is the net balance of energy consumption post-retrofit and baseline energy consumption pre-retrofit. Epost is the total energy consumption for a building after a retrofit. Epre is the total energy consumption for a building before the retrofit.

3.2 Routine Baseline Adjustment

Routine adjustment is energy use that may be adjusted based on independent variables such as weather, occupancy, ambient temperature, and business hours. This study considers two variables: Cooling Degree Days (CDD) and working days. The determination of CDD formulation is related to the temperature mean value, which is indicated in Eq. (3). Meanwhile, the given Eq. (4) computes the value of the CDD. However, in this study, the nearby weather station has been identified where the value of CDD per day was collected from the website.

$$\text{TM}=\frac{(\text{Max. Temp.} + \text{Min. Temp.})}{2} \tag{3}$$

$$\text{CDD=Temperature mean-65°F} \tag{4}$$

Where TM is the total temperature mean for a day, Max. Temp presents the highest temperature for a day, Min. Temp. is the lowest temperature for a day, and CDD refers to the cooling degree days for a day.

*Note: The definition of Degree days is the difference between the daily temperature mean and base temperature (65°F).

In this study, the investigation was done in a university management building. Therefore, standard working hours (office hours) are used. All the government offices are open five days a week (Monday to Friday), and normal office hours are from 8 a.m. to 5 p.m. To find the correlation to establish the baseline adjustment model, the Linear Regression Model (LRM) is developed in excel based analysis. The LRM is a linear model in single regression or equating two or more variables linearly. The linear regression model displays the interchange amount experienced in a variable by the changes in the other variables. Thus, the multiple linear regression equation model is presented in Eq. (5) accordingly. However, this study only considers a single regression model to define the correlation between energy consumption and CDD as the focused variables since the climate issues on the outside and inside weather for the commercial building. Meanwhile, Chiller operating hours are recorded and applied in a normalized process to establish the baseline model for the actual energy saving determination.

$$Y = \beta 1X1 + \beta 2X2 + \cdots + \beta nXn + \beta 0 + \varepsilon \tag{5}$$

Where, X is the independent variable that equates to the dependent variable Y. (X is input & Y is output); β is the coefficient of the independent variables. (It is determined by Least Square Method) and ε represents the constant value of C.

3.3 Energy Generation from Solar PV

The estimated energy produced by installed solar PV is determined by using the energy yield equation as presented in Eq. (6):

$$\text{Energy yield}=\text{P array}_{\text{stc}}\times \text{Irradiation} \times \text{k}_{\text{deration}}(\text{losses}) \tag{6}$$

Where, $\text{P array}_{\text{stc}}$ is PV module rated power; Irradiation presents the solar irradiation (unit: kWh/m^2). While $\text{k}_{\text{deration}}(\text{losses})$ is the losses calculated using derating factors.

3.4 Net Energy Metering (NEM) Scheme Formulation

As it is frequently exposed to the sun throughout the year, Malaysia can be considered a potential country for high-power generation from solar PV systems [30]. Malaysia is located in the equatorial region with annual solar radiation of 1643 kW/m^2 [31]. Considering the potential of solar energy and the significance of renewable energy (RE) in Malaysia, various policies have been established to persuade the public, including residential customers, to have their renewable energy systems. Net energy metering (NEM) is a scheme that encourages the use of customer-owned distributed generation (DG) resources (such as solar photovoltaic panels or PVS) by compensating DG customers at the retail rate for each kWh of generation [32], which details explanation about the scheme has been presented in [33-35]. Thus, a general mathematical formulation of the existing electricity bill with NEM scheme is presented in Eq. (7) and Eq. (8), respectively.

$$\text{P}_{\text{total}}^{\text{net}}= \text{P}_{\text{total}}^{\text{consumption}}-\text{P}_{\text{total}}^{\text{generate}} \tag{7}$$

$$\text{Electricity bill}=\text{P}_{\text{total}}^{\text{net}}\times\text{Price}^{\text{tariff}} \tag{8}$$

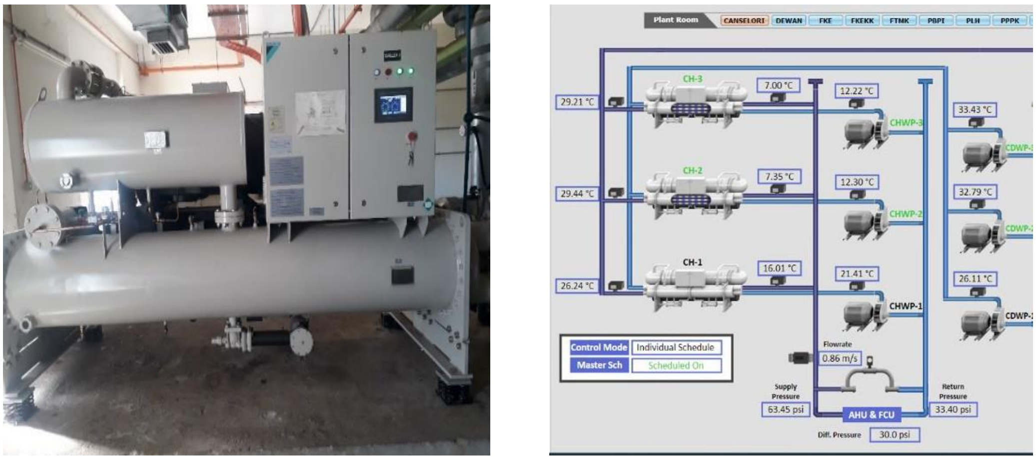
Where, $\text{P}_{\text{total}}^{\text{consumption}}$ is the total energy consumption for a building in a month. $\text{P}_{\text{total}}^{\text{generate}}$ is total energy generation for a building in a month. $\text{P}_{\text{total}}^{\text{net}}$ represents total net balance of energy consumption and generation. $\text{Price}^{\text{tariff}}$ refers to standard domestic tariff rate based on offer by energy provider. Meanwhile, Electricity bill represents the total electricity bill for a month.

4. Results and Discussion

This section demonstrated the research output with two incredible analyses for Option B and Option C considering the M&V methods.

4.1 Option B: Chiller Retrofitting Analysis

There are three chillers in this building. However, two out of three have been operated on during the data collection. They are Chiller 2 and Chiller 3. Both chillers have been upgraded from the old type to the energy efficiency chillers since 2019. Yet, the size of the new chillers is upgraded from 150RT to 210RT, which is about 19% of the sizing increment. The decision to chillers' size upgrading is also related to the extension of the building's capacity, which is the size of the staff population in the building. Hence, Figure 4(a) presents the new retrofit operated chiller in the building. In contrast, Figure 4(b) shows the chiller plant configuration controlled through the Building Management System (BMS), respectively.



Control Mode: Individual Schedule
Master Sch: Scheduled On

(a) (b)

Fig. 4. Chiller System. (a) Picture of the retrofitted chiller at management building; (b) Chillers configuration that has been monitored through BMS system

The power consumption was collected using a power meter logger for one week before installing new chillers. The recorded is set as the baseline for the following calculation. Meanwhile, Table 2 demonstrates the data of baseline energy consumptions and Cooling Degree Days (CDD) before retrofitting for Chiller 2 and Chiller 3. The recorded baseline energy consumption on Saturday and Sunday is 0 kWh during the non-operation period.

Table 2
Before retrofit: chillers' energy consumption recorded during working hours for one week

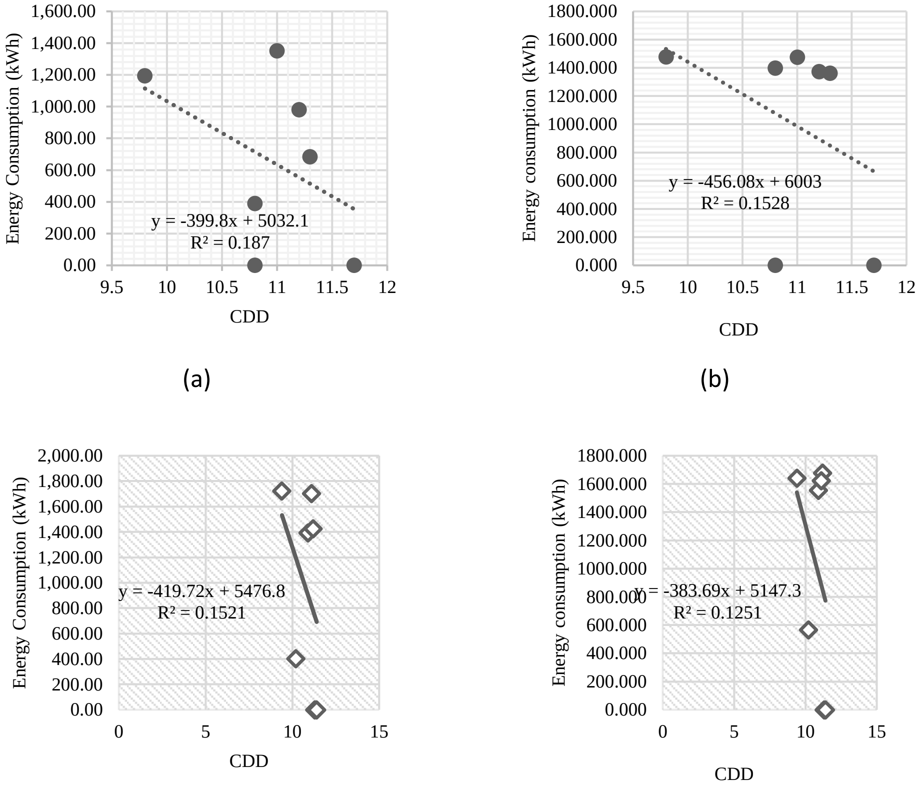
Day	CDD	Chiller 2: Baseline Energy Consumptions (kWh)	Chiller 2: Baseline Energy Consumptions (kWh)
Monday	10.8	390	1398
Tuesday	11	1351	1474
Wednesday	9.8	1194	1478
Thursday	11.2	980	1372
Friday	11.3	685	1362
Saturday	11.7	0	0
Sunday	10.8	0	0

On the other hand, Table 3 shows the data for energy consumption and Cooling Degree Days (CDD) after retrofit for Chillers 2 and 3 that have been recorded after the commissioning process of new chillers installation. The taken data is set as the post-retrofit energy consumption data. The post-retrofit energy consumption on Saturday and Sunday is 0 kWh, equal to the baseline. Meanwhile, the highest energy consumption for both chillers is on Monday and Thursday, approximately 1,723 kWh and 1,677 kWh, respectively. The average CDD value for the baseline is recorded at a little lower, about 10.7, compared to the baseline value. During the process, it was observed that the post-retrofit data was higher than the baseline without considering significant variables toward energy consumption.

Table 3
After retrofit: chillers energy consumption recorded during working hours for one week

Day	CDD	Chiller 2: Post-Retrofit Energy Consumptions (kWh)	Chiller 3: Post-Retrofit Energy Consumptions (kWh)
Monday	9.4	1,723	1,641
Tuesday	10.2	403	567
Wednesday	10.9	1,394	1,554
Thursday	11.2	1,426	1,677
Friday	11.1	1,703	1,623
Saturday	11.3	0	0
Sunday	11.4	0	0

Figure 5(a) shows the correlation of Cooling Degree Days (CDD) concerning the baseline energy consumption using single regression for Chiller 2 before the retrofit. The single regression model correlation results revealed that the R^2 value is 0.187. The single regression model yields regression for Chiller 2 before retrofit is shown in the figure. Figure 5(b) presents the correlation of Cooling Degree Days (CDD) for the baseline energy consumption using single regression for Chiller 3 before the retrofit. The single regression model correlation results revealed that the R^2 value is 0.1528. In conjunction with that effort of chillers retrofitting, Figure 5(c) and Figure 5(d) demonstrate the correlation of Cooling Degree Days (CDD) to after-retrofit energy consumption by using single regression for Chiller 2 and Chiller 3 separately.



(a) (b)

(c) (d)

Fig. 5. Regression results of energy consumption versus CDD for (a) Chiller 2 before retrofit; (b) Chiller 3 before retrofit; (c) post-retrofit of Chiller 2; (d) post-retrofit of Chiller 3

The single regression correlation between energy consumption and cooling degree days results has presented that the R^2 values s are 0.1521 and 0.1251 for both chillers. Considering all the correlation results, it was observed that the R^2 values obtained from the analysis are less than the indicator level, which is 0.75. Thus, it can be concluded that the CDD has a less significant impact on the energy consumption in a building during the setting up of the baseline adjustment study data for both chillers.

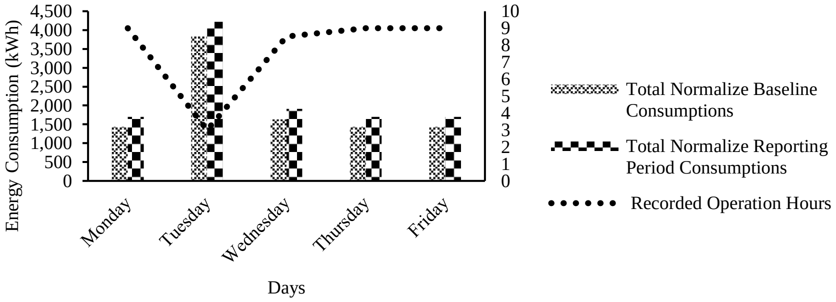


Fig. 6. Normalization results considering operation hours data for Chiller 2n

However, when considering the other variable, such as operation hours, the significant output of the actual energy avoidance has changed tremendously. The exact value of operation hours from baseline data has been applied to both chillers in generating the post-retrofit energy avoided value. Figure 7 illustrates the calculation of energy saving for Chiller 2 accordingly. The total energy consumption for post-retrofit is 11,224 kWh compared to the total baseline consumption of about 9,768 kWh. The energy-saving obtained increases by approximately 1,457 kWh or 15% increment. It was pragmatic that the sudden change in chiller refrigerant capacity would increase chiller power consumption. Instead of increasing the energy consumption for post-retrofit on Chiller 2, Figure 7 presents the odd results of Chiller 3 performance. The total energy consumption of Chiller 3 for post-retrofit is around 10,964 kWh; instead, the absolute baseline consumption is about 12,455 kWh. Hence, the adjusted total energy saving for Chiller 3 retrofitting is approximately 1,491 kWh or a 12% reduction. It was analysed that the comparison of the chiller confidence is increasing much better compared to the existing old chiller. So, it can be concluded that even though the refrigerant capacity of Chiller 3 has been increased. Still, the energy consumption sank to a better percentage due to the old chiller's inefficient condition.

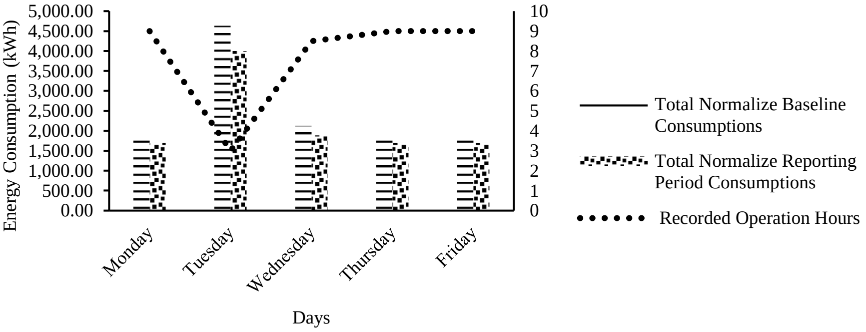


Fig. 7. Normalization results considering operation hours data for Chiller 3

4.2 Option C: Solar PV Installation Case Study Analysis

The energy production from solar PV installation and the regression analysis results of building energy consumptions towards variables such as CDD and No. of working days will be analysed in this section. The data of annual building energy consumptions before and simulation of NEM implementation are discussed while the cases of study have been divided into three conditions as follows:

i. Case 1: Installation of100kWp of Rooftop Solar PV
ii. Case 2: Installation of 200kWp of Rooftop Solar PV
iii. Case 3: Installation of 300kWp of Rooftop Solar PV.

Since the Solar PV installation is limited for only 1MWatt capacity of a government building, the maximum capacity set for the building is 300kWp only. The rest of the capacity balance is to be installed in other buildings. Besides, the rated power of the solar PV module, the value of solar irradiation, and the value of losses calculated using derating factors are also vital to determine the energy produced by solar PV. The average value of solar irradiation in the retrofit year was 144.75 kWh/m2, and the total annual irradiation was 1731 kWh/m2. Meanwhile, the value of losses calculated using derating factors presented the total system performance value of approximately 0.795. It is shown that the value is valid for the performance and efficiency of solar PV calculation.

Figure 8 demonstrates the tabulated energy consumptions computed from the simulation of Solar PV installation. The monthly energy production from 100-300 kWp solar PV system is determined using Eq. (6). For all cases, the month that produced the highest energy is March, about 12,955 kWh, 25,910 kWh and 38,865 kWh, respectively. Meanwhile, the average energy production for Case 1: was 11,507 kWh; Case 2: 23,009 kWh and Case 3: 34,514 kWh.

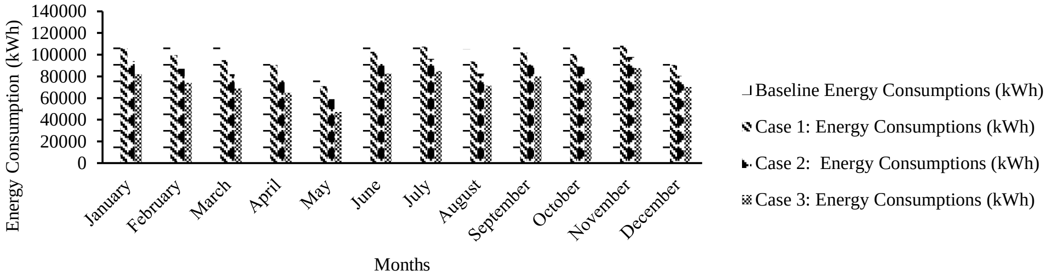
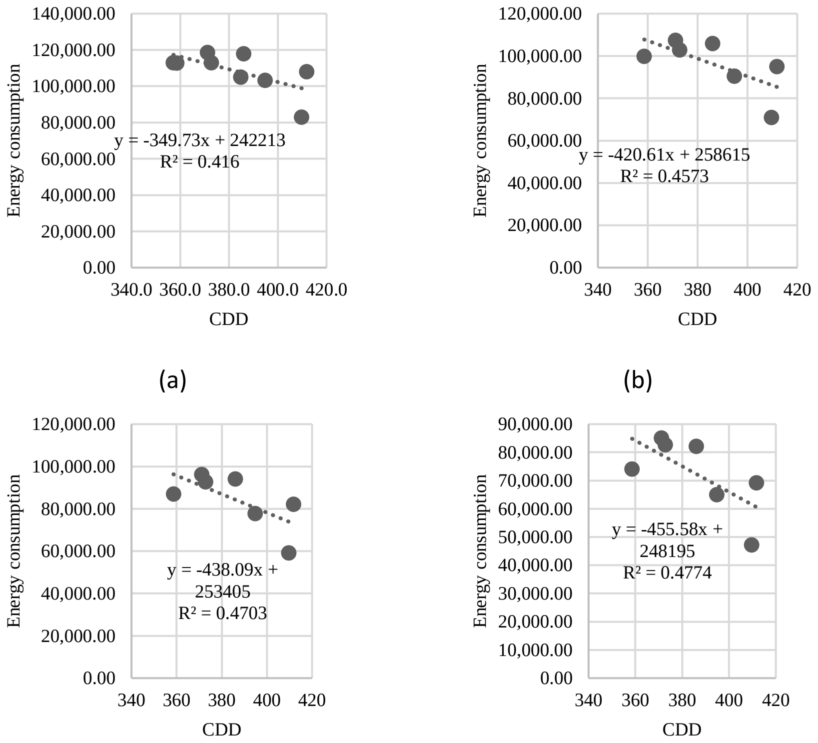


Fig. 8. Comparison of energy consumption for all cases to the baseline for 12 months

Apart from that, Figure 9 presents the regression analysis of the energy consumption and CDD for all the cases. It was observed that the increase in solar capacity installation would increase the value of R2. Since the energy consumption is high for the building, the significant correlation value to the CDD has increased compared to the single chiller energy consumption.



(a) (b)

(c) (d)

Fig. 9. Regression analysis of the correlation between energy consumption and CDD with the following cases: (a) baseline; (b) Case 1; (c) Case 2 and (d) Case 3

The multiple regression has been made to two variables concurrently. They are No of Working Days (WD) and CDD. Hence, the summary of the normalized results of the adjusted energy consumption for all cases is presented in Table 4 accordingly. It was analysed that the saving percentage of Case 3 is highest while Case 1 provides losses value. Even though installing Solar PV will bring significant savings on energy consumption, with the trim panel installation capacity, the minimum saving cannot be achieved. Therefore, Case 3 was selected to be the best installation capacity for the building.

Table 4
Normalization consumption considering multiple variables of CDD and No. of Working Days

Month	No. of Working Days	Normalize Baseline Consumptions (kWh)	Case 1: Normalize Reporting Period Consumptions (kWh)	Case 2: Normalize Reporting Period Consumptions (kWh)	Case 3: Normalize Reporting Period Consumptions (kWh)
January	181	178,807	182,358	173,979	165,598
February	216	166,776	167,889	158,909	149,926
March	183	178,142	181,559	173,147	164,733
April	184	177,863	181,223	172,796	164,368
May	156	187,725	193,084	185,151	177,216
June	178	179,891	183,662	175,337	167,011
July	186	177,058	180,255	171,789	163,320
August	162	185,557	190,476	182,434	174,391
September	178	179,926	183,704	175,381	167,056
October	173	181,885	186,060	177,834	169,607
November	192	174,960	177,732	169,160	160,587
December	180	179,436	183,116	174,768	166,418
Total	2,169	2,148,027	2,191,119	2,090,687	1,990,233
Average	180.74	179,002.22	182,593.25	174,223.88	165,852.71
Diff. (%)			-2.01	4.58	4.80

The summary of the energy and cost-saving performances is shown in Table 5. Total saving for both significant programs is approximately 10.65%, which is considerable for investment and planning. It was observed that installing solar PV will provide a better solution to support energy-saving initiatives by the university.

Table 5
Summary of the energy and cost savings for the optimum chiller retrofit and NEM scheme

Program	Yearly Energy Saving (kWh)	Yearly Cost Saving (MYR)
Retrofit Chiller 3	71,568	26,122.32
Installation of 300kWp solar PV	157,794	57,594.80
Total Saving	229,362	83,717.1

5. Conclusion

In this study, the baseline adjustment of significant variables is analysed using regression analysis to obtain the same variable that affects the energy consumption of the building. The single regression model correlation of both chillers shows a small value of R2. The correlation between energy consumption and the independent variable is least correlated and poorly impacts a chiller plant's energy consumption. Meanwhile, both chillers' multiple regression model correlations show the more excellent value of R2, while the normalization method has been used to produce the adjusted energy consumption. Furthermore, when the NEM scheme is implemented, an increase in the value of the R2 can be observed. The significant value of the energy consumption is produced based on multiple variable considerations: CDD and WD by using Option C. It is demonstrated that the combination of independent variables is highly correlated and directly impacts the energy consumption in a building. It is proved that optimum saving can be obtained with the implementation of the NEM scheme simultaneously. The combination of independent variables can be varied for future improvements to get a better regression analysis result. Another approach that can be applied is using forecasting algorithms, and machine learning techniques such as in [36] by Muhammad, Mohd Amin and Adnan and fuzzy technique in [37] by Nik Hassan *et al.,* to forecast energy load profiles and normalized savings in the building. This approach will give a better and more accurate result.

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