Energy Efficiency Study at SSAAS Building

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***Abstract*— Energy Efficiency study in Sultan Salahuddin Abdul Aziz Shah (SSAAS) Building, Shah Alam is to find the method to reduce the maximum demand, starting current and the bill of SSAAS building. It is use the Autotransformer and Capacitor Bank as the mitigation to reduce the maximum demand and starting current in the systems. The data have collect by weekly every month using Power Logger (Fluke 1735). From the data collected by weekly, it is proving that the Autotransformer and Capacitor Bank reduce the starting current, maximum demand and the bill of the SSAAS Building. The data that have been collected from the system show the different between before and after install the Autotransformer and Capacitor Bank.**

Keywords- Autotransformer, capacitor bank, tariff.

INTRODUCTION

Sultan Salahuddin Abdul Aziz Shah (SSAAS) Building is a government building which was first conducted to reduce the starting current and maximum demand. Bill to be paid by the electricity consumption in buildings is relatively high is about RM 400,000.00 per month and the studies focus on how to reduce the bill to be paid in addition to reducing the maximum demand on the building. In this study, the method used to reduce the amount of electricity bills to be paid is using Autotransformer and capacitor banks, autotransformer and capacitor banks are used to replace the star delta systems to reduce the starting current, maximum demand and the bill of the SSAAS building.

A. Capacitor Bank

Capacitors have been commonly used to provide reactive power compensation in distribution systems. They are provided to minimize power and energy losses, maintain best voltage regulations for load buses and improve system security. The amount of compensation provided is very much linked to the placement of capacitors in the distribution system which is essentially determination of the size and type of capacitors to be placed in the system In general, capacitor banks are installed in power systems for voltage support, power factor correction, reactive power control, loss reduction, system capacity increase, and billing charge reduction. This process involves determining capacitor size and connection type .The main effort usually is to determine capacitor size and location for voltage support and power factor correction. Secondary considerations are harmonics and switching transients [1].

B. Autotransformer

Transformers are valuable equipment which makes a major contribution to the supply security of the power system. Optimum design of the transformer protection ensures that any faults that may occur are found quickly, so that consequential damage is minimized. A special variant is the so-called autotransformer in which, unlike in the full transformer, the voltage and current transformation is not performed by two independent windings but uses part of the winding from both sides, allowing a much more compact design. The spectrum of autotransformers ranges from small distribution system transformers (from 1000 kVA) to large transformers of several hundred MVA. Their use becomes more interesting, the less the ratio between the high-voltage (HV) side and low-voltage (LV) side deviates from 1, i.e. the less energy is transmitted via the magnetic coupling which leads to a saving in iron material.

C. Tariff

According in Table 1, in Jun 2011 TNB tariff rise and affect the bill of the SSAAS building. It is one of the factors to study how the bill could be reduced by using the Autotransformer and capacitor banks. Using the new system has been installed, the total bill to be paid is still lacking despite the tariff TNB has increased from RM23.93/kW to RM25.90/kW [2].

Tariff	Hourly use (cent/kWh)	Max. Demand (Rm/kW)
Old	28.8	23.93
New	31.2	25.90
*Increase	2.4	1.97

**average increase of 8.3%*

Table 1

METHODOLOGY

Power Logger (Fluke 1735) is probes that use to get the data from the systems. The data collected by weekly in Mei 2011 until July 2011. The data from the weekly will show the result after the implement of the 4 Steps Autotransformer and capacitor bank will reduce the starting current, maximum demand and SAAS building of not.

According to Figure 1, before using 4 Steps Autotransformer and Capacitor Bank system, Star Delta system has been used in the SSAAS Building and its show the starting current of the motor is high. The power Factor for the system also is less than 0.85 and it is imposed a penalty by TNB. In this system, 4 Steps Autotransformer and capacitor bank is installed close to and parallel with the load (motor) to achieve greater efficiency in the Mechanical Room.

Autotransformer and Capacitor Bank systems have not yet adopted in any system of electrical installation in any building, and here it is applied in SSAAS building as the beginning. Method of installation of this system makes Optimal Capacitor Placement near to the source of the motor (control at source). It is different when compared with conventional assembly mounted adjacent to the MSB.

According to this system, Autotransformer is use to reduce the starting current and maximum Demand of placement period. Capacitor banks are used to reduce power losses and improve power factor.

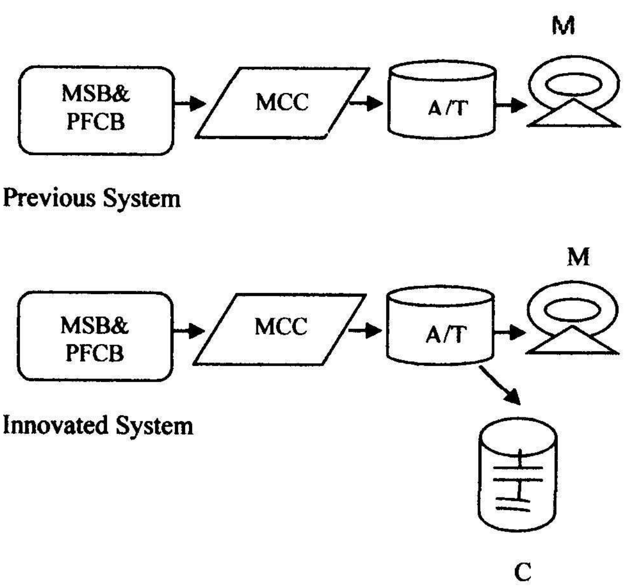

Figure 1. Simplified Electrical Circuit Layout Diagram of the Operating Motor pump

Notes:

MSB: Main Switch Board
S/D: Star Delta
A/T: Autotransformer
C: Optimal Capacitor
PFCB: Power factor Circuit Breaker
MCC: Motor Control Consul
M: Motor

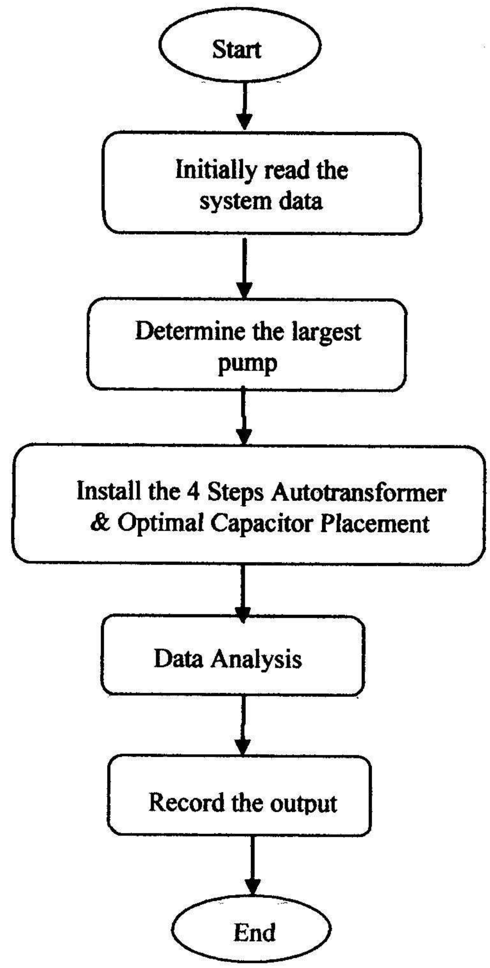

Figure 2: Flow of the studies

According to Figure 2, a flow chart describing the flow to get the complete data after the system install Autotransformer and Capacitor Bank system. Before installation Capacitor Bank and Autotransformer system, data is collected during the Star Delta system by using Power Logger (Fluke 1735). The data must taken before install the Autotransformer and Capacitor Bank systems cause to know the reading before it is install. After the data from the Star Delta system has been known, Capacitor banks and Autotransformer system is install. Data retrieved and analyzed by using Power Logger (Fluke 1735) whether there are changes in the power factor and maximum demand. Data is recorded in state for several months to make the information available and accurate. Data is recorded and made study whether this system is efficient or not.

Equation for Kvars required to change power factor is described as below:

Power (P) = $\sqrt{3}$ Current (A) x Voltage (V) x Cos Ø [eqn 1]
Power factor = Pf = Cos Θ = kW/kVA = kvar/kW [eqn 2]
kVAR = kW (Tan Θ_1 – Tan Θ_2) [eqn 3]

Where $\Theta_1 = \text{Cos}^{-1}$ Pf = Initial Angle Power Factor
Where $\Theta_2 = \text{Cos}^{-1}$ Pf = Final Angle Power Factor

It is necessary to know the load variation data during the year in order to obtain a cost effective of the electrical consumption. The proposal method essentially follows the largest motor pump at each utility. The proposed method is applied to 180 hp motor pump of induction Motor. It is located at Lower Ground at Switch Room of Sultan Salahuddin Abdul Aziz Shah (SSAAS) building, Shah Alam.

RESULT AND DISCUSSIONS

For the convenience of comparison, two cases are studied below. Their results are presented in Table 2. Value of inrush current has been decrease from 384.95A to 370.76A. The voltage in this system 423V and the frequency about 50 Hz. The result show inrush current in proportional to Maximum Demand. The decrement of the Maximum Demand will affect low bill payment for the SSAAS Building.

Parameters	Before Implementation	After Implementation
Inrush Current	384.95 A	370.76 A
Current	216.87 A	192.76 A
Reactive Power	88.17 kVAR	44.76 kVAR
Apparent Power	155.52 kVA	135.01 kVA
Power factor	0.836	0.976
THD A	61.7%	47.3 %
Energy Efficiency	0.995	

Table 2: Table of comparative implementation results

The power factor of the innovated system is greater than before the implementation. Table 2 show the power factor has been improved from 0.836 to 0.976. Penalty can be charge if the power factor below than 0.85. According to the table 3, its shows the data by weekly from Mei 2011 until end of July 2011

Weekly	Pf	Inrush current	Current	THD A	
1 (Mei 2011)	0.828	389.24	220.14	63.76%	
2 (Mei 2011)	0.834	392.12	219.22	64.35%	Before Install
3 (Mei 2011)	0.845	388.87	214.23	61.9%	
4 (Mei 2011)	0.836	384.95	216.87	61.7%	
5 (Jun 2011)	0.976	370.76	192.76	47.3 %	
6 (Jun 2011)	0.987	371.42	190.13	45.15%	
7 (Jun 2011)	0.988	369.87	190.24	47.3%	After Install
8 (Jun 2011)	0.982	370.14	191.32	42.4%	
9 (July 2011)	0.986	371.28	191.47	40.4%	
10 (July 2011)	0.979	370.18	194.76	47.1%	
11 (July 2011)	0.975	369.98	198.14	46.45%	
12 (July 2011)	0.982	372.14	190.73	44.15%	

Table 3: Data in weekly

From the case study, the charges of bill payment are depending of the uses of Maximum Demand in SSAAS Building. This statement can be concluding from the Table 3, data in weekly show how the power factor and Total Harmonic Distortion of the Data will change when the Autotransformer and Capacitor Bank system is install.

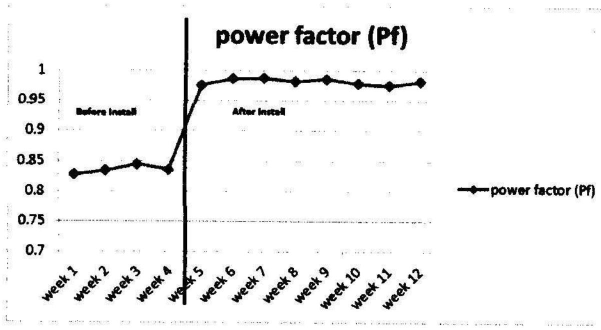

Figure 3: Graph of the Power Factor

According to the Figure 3, the power factor before and after install the Autotransformer and Capacitor Bank is different. After install the Autotransformer and Capacitor Bank, the power factor of the system near to "1" power factor and before install the Autotransformer and capacitor Bank, the Power factor below then 0.85 and penalties imposed on SSAAS Building.

According data in Table 4, its show the total bill payment from April 2010 until March 2011 decrease when using Autotransformer and Capacitor Bank in the system. From the theoretical study, the value of Maximum Demand is the major cause that will effect consumers' bill payment.

Bil	Date of Bill	Max demand (MD)	Charges Max Demand (RM)	Total Bill Payments (RM)
1	1 Apr 10	4,460.00	106,943.00	445,804.35
2	1 May 10	4,623.00	110,628.39	438,378.40
3	1 jun 10	4,625.00	110,676.25	435,475.40
4	1 Jul 10	4,438.00	106,201.34	415,552.45
5	1 Aug 10	4,450.00	106,488.50	436,859.60
6	1 Sept 10	4,181.00	100,051.33	386,392.40
7	1 Oct 10	4,224.00	101,080.32	364,272.80
8	1 Nov 10	4,357.00	104,263,01	430,417.50
9	1 Dec 10	4,445.00	106,368.85	419,040.05
10	1 jan 11	4,152.00	99,357.36	404,332.05
11	1 Feb 11	3,945.00	94,403.85	371,308.60
12	1 Mar 11	4,185.00	100,147.05	365,047.20

Table 4: electricity bill Consumption

Graph in figure 4 shows the improvement of Maximum Demand of electricity usage after the implementation of innovated system.

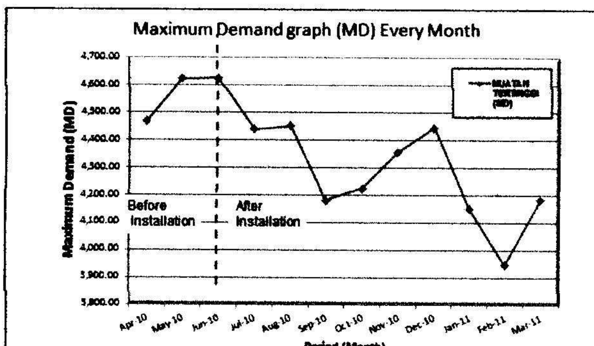

Figure 4: Graph Maximum Demand of electricity usage

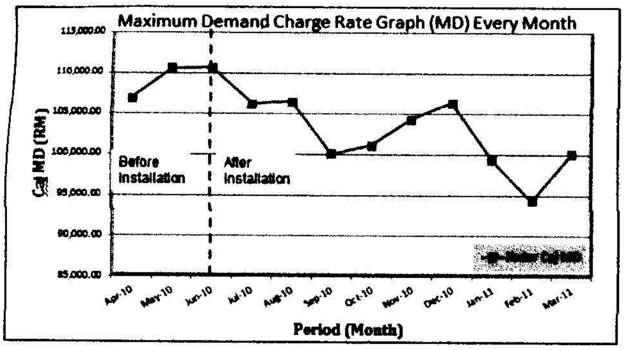

Figure 5: Graph Rates MD in each month

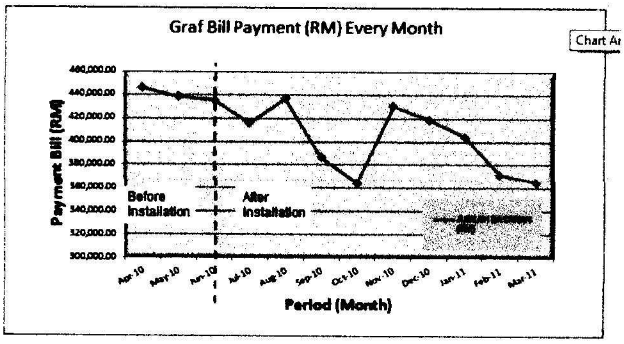

Figure 6: Graph of Electrical Bills in each month

Maximum Demand (MD) and overall electricity charges reduced compared to before installation as shown in Figure 5 and Figure 6.

Return on investment (ROI) is a performance measure used to evaluate the efficiency of investments. To calculate ROI, the benefit (return) on an investment is divided by the cost of the investment; the result is expressed as a percentage or a ratio.

The return on investment formula (ROI):

$$ROI = \frac{\text{Gain from Investment} - \text{Cost of Investment}}{\text{Cost of Investment}}$$

In order to estimate the payback costs, energy saving after implementation of 4 steps Autotransformer and Capacitor Bank Placement per year. From the result after implementation the ROI is about 36% per annum.

The two equipment adopted in this work. A practical test system is used to demonstrate the effectiveness of the proposed methods. It is found that the power losses and reduction starting current are sensitive to the proposed methods. The proposed technique has been developed with consider the load characteristics into account. The developed method has been tested in a distribution system. The results show the integration of 4 Steps Autotransformer and Capacitor Bank Placement is highly effective in reducing Maximum Demand, minimized total power losses and reduce starting current.

CONCLUSION

From data and information obtained, the bill payments and the high maximum demand from the SSAAS building can be reduced based on data collection. Before installation the autotransformer and capacitor banks systems, star delta systems have been used and the difference can be seen by the data. From the data collection, the power factor before installation Autotransformer and capacitor banks is less than 0.85 and penalty is imposed, and after install the autotransformer and capacitor bank, the power factor has improved of 0.90. Autotransformer and capacitor bank system also causes the motor starting current of the pump is reduced. Autotransformer and capacitor bank systems also has not previously used or installed in any building and the SSAAS building became the first building using Autotransformer and capacitor bank system and its found that the bill, maximum demand and the starting current has reduce.

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