The International Journal of Engineering and Science (IJES)
|| Volume || 11 || Issue || 4 || Series I || Pages || PP 18-25 || 2022 ||
ISSN (e): 2319-1813 ISSN (p): 20-24-1805

Implementation Of Demand Side Management At Siantan Substation for Load Factor Improvement

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--- ***ABSTRACT***---

Siantan substations located within the west Kalimantan electrical system, known as Khatulistiwa GI system consists of 11 feeders. Including cottage, beting, navigasi, hoktong, tugu, wilmar, pangeran, selat panjang, vitamo, malaya dan puring 1. in 2019, the usage of electrical energy at the Siantan substation from customers is still suboptimal yet, cause the uneven use of electrical energy during peak load times (PLT) and outside peak load times (OPLT), causing a low load factor value of 0.84. This is certainly detrimental to all parties, both for PLN itself and for customers. Thus, it is necessary to have a system to assist in increasing the value of the load factor, namely by Demand Side Management (DSM) with the load shifting method. DSM is the scheming, implementation, and monitoring of utility activities designed to affect the customer's electricity usage in a way that will result in the desired changes in the form of utility loads, i.e. changes in the time pattern and magnitude of utility loads. Load shifting means moving the load from the PLT period to the OPLT period. In this study, a simulation of the application of the DSM load shifting method uses 4 scenarios with variations in time and load values. From the simulation, scenario 1 has a load factor value of 0.90 with a savings of 13.13% per year, scenario 2 has a load factor value of 0.87 with a savings of 5.83% per year, scenario 3 has a load factor value of 0.89 with a savings of 11.36% per year and scenario 4 has load factor value of 0.88 with a savings of 8.61%.

Key Words : *Substation, DSM, Load Shifting, Load Factor*

Date of Submission: 01-04-2022 Date of Acceptance: 10-04-2022

I. INTRODUCTION

Electricity System in West Kalimantan known as the Khatulistiwa System, Siantan GI is part of the Khatulistiwa System. GI Siantan consists of 11 feeders, including cottages, shoals, navigation, hoktong, monument, wilmar, prince, long strait, vitamo, malaya, and puring 1.

Based on the daily load data of PT. PLN (Persero) in 2019, the use of electrical energy by customers is still not optimal, namely the uneven use of electrical energy at the time of WBP and LWBP, causing the load factor value to be low, namely 0.84. This of course has a detrimental impact on all parties, both for PLN itself and for customers. Therefore, it is necessary to have a system to increase the value of the load factor, namely by applying DSM with the load shifting method. Based on the provisions of PLN, the Peak Load Time (WBP) is at 17.00 – 22.00 WIB (Agus Mulyadi et al 2017)[1].

According to Gellings (1985), the DSM approach will provide mutual benefits for the customer and the power company. For customers, the benefits are reduced electricity bill costs during WBP and for the power company itself it can delay the construction of new power plants and make the load curve more evenly distributed during peak and off-peak loads [2].

With DSM consumers can save on electricity bill costs by changing their consumption patterns and for utilities can reduce generation requirements during peak hours, which offers operational flexibility and benefits for utilities (Dario Javor et al 2016)[3].

Energy saving is a major part of the design concept in the operation of the substation. Energy efficient substations can provide good social, environmental and economic benefits for future engineering designs (Guangming Wang et al 2020) [4]. More generating units is not the only solution to meet the increasing demand for electrical energy, because there are many things that must be considered for the establishment of new plants, such as limited land, limited resources (wind, solar radiation, water) ecology etc. (Majid Jamil 2020) [5](S Barbarelli 2018)[6](G Piras 2019)[7].

According to Satoshi Nakano 2020, saving on the use of equipment is not the only solution to global warming, another way that can be done is by changing the behaviour of using household appliances by consumers from one period of time to another [8]. According to K. Lebedeva et al 2021, to meet peak demand is one of the reasons that causes increased emissions from power plants, because it is usually met by basic generation loads that are fossil fuelled (natural gas, oil, etc.)[9].

Balasubramaniyan S 2015 in his research said, with DSM power distribution units can change the user's load schedule by encouraging users to shift their load devices outside of peak hours, thereby reducing customer billing costs and also lowering PAR (Peak to Average Rate)[10] . DSM is the process of managing energy consumption to optimize the available and planned resources for power plant. DSM combines all activities that affect the customer's electricity usage, which is mutually beneficial for both the customer and the power company (Niharika V M 2018) [11]. According to Dario Javor 2016, DSM is one solution to manage electricity consumption in developing countries [12].

On the customer side, DSM means an opportunity to save money by reducing the cost of their electricity bill by taking advantage of the price incentives provided by the utility (Eze C U et al 2016)[13].

Similar studies have been conducted to obtain formulas for modeling DSM problems, including: Anatoly Dzyuba et al (2020) developing a price-based DSM model for industry and large electricity consumers [14], T Logenthiran et al (2011) using the Multi Agent System (MAS) [15], Iqbal Zafar et al (2016) used the ECG optimization model [16], Zubair et al (2014) used the GTES optimization [17] and many others.

Chaimongkan C (2015) said Load shifting is one of the simplest load management methods, namely reducing customer demand during peak loads by shifting the use of equipment and supplies to periods outside of peak loads [18]. Arvind R (2017) said that the load shifting method could delay the construction of a new factory to meet peak load demands [19].

With the application of the DSM load shifting method that involves time variations and the value of the load on the Siantan GI, it is hoped that several benefits will be obtained, including getting a load factor value close to 1 and reducing the cost of electricity bills.

II. METHOD

In this study, the process of carrying out the research, which consists of processing data results from the application of 4 DSM scenarios, the load shifting method. The research flow chart is shown in Figure 1.

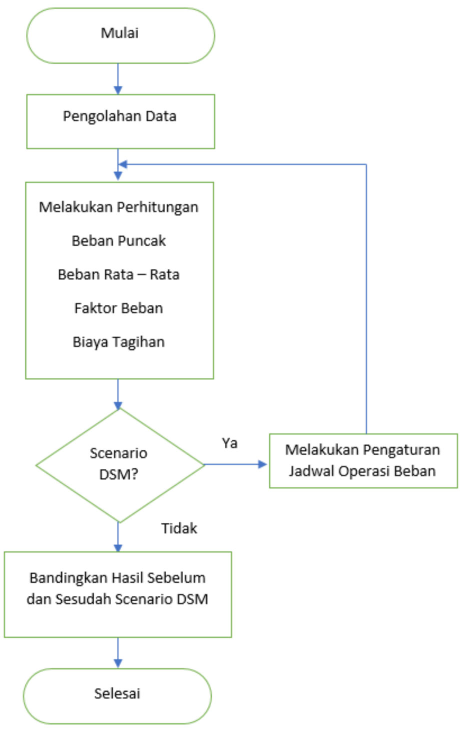

Figure 1. Research Flowchart

III. RESULTS

1. Research Data

The data used is in the form of secondary data, namely data obtained from UP2D PT. PLN (Persero) West Kalimantan, which is in the form of 24-hour daily load data for 1 year (annual average load), namely 2019 at the Siantan GI which is shown in Figure 2.

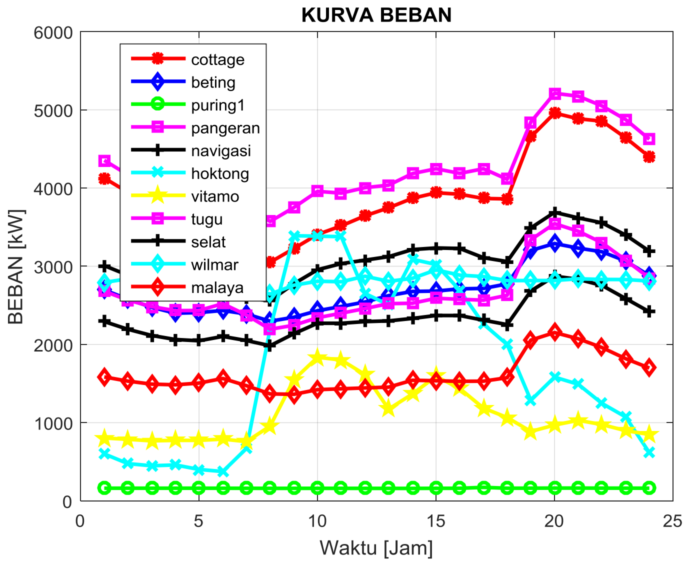

Figure 2. Graph of the 2019 Siantan GI Average Annual Load (Real Power)

In Figure 2 it can be seen that the Siantan GI consists of 11 feeders, namely: cottage, shoal, puring 1, prince, navigation, hoktong, vitamo, monument, strait, wilmar, and malaya. Feeders that having peak loads during PLT (at 19.00) were cottages, shoals, princes, navigation, monuments, straits, and malayas. The peak load of Puring 1 is at 16.00, Hoktong is at 08.00, Vitamo is at 09.00 and Wilmar is at 14.00.
In this study, 4 DSM scenarios were simulated using the load shifting method with variations in time and load values on the annual average load data using the Matlab application. The 4 DSM scenarios below:

1. Makes each 13-load regulator with a value of 800K
2. Makes each 13-load regulator with a value 2000 kW
3. Makes each 8-load regulator with a value1500 kW
4. Makes each 5-load regulator with a value 1500 kW

The regulated load is the operating load when the PLT (18.00 – 22.00) is transferred to the OPLT.

2. Demand Site Management

DSM is the scheming, implementation, and monitoring of utility activities designed to influence electricity usage by customers in a way that will result in the desired changes in the form of utility loads, i.e. changes in the time pattern and magnitude of utility loads [2]. DSM aims to encourage consumers to use less energy during peak hours (Christine C B 2020)[20].

3. Load Shifting

Load shifting means moving the load from the on peak period to the off peak period [2]. The load shifting technique is the best solution from the utility company's point of view. With this technique, the demand for electrical energy is transferred from WBP to LWBP [12]. The advantage of using this technique is that the load increases during LWBP, in other words, there is an even distribution of load between WBP and LWBP but there is no change in total energy consumption. This of course affects the value of the load factor. The load factor value can be obtained through equation (1)[21]:

$$LF = \frac{Average\ Load}{Peak\ Load} \quad (1)$$

Where : LF = Load Factor
$Average\ Load$ = Average Load (kW)
$Peak\ Load$ = Peak Load (kW)

Average Load can be calculated using the equation (2)[12]:

$$Average\ Load = \sum_{j=1}^{J} P_{(j)} t_{(j)} / \sum_{j=1}^{J} t_{(j)} \quad (2)$$

Where : $Average\ load$ = Average Load (kW)

$P_{(j)}$ = The amount of electrical energy used (kW)
$t_{(j)}$ = Times in unit of hour (hour)

$$C = C_d + C_e \quad (3)$$

Where : C_d = Load Cost (Rp)
C_e = Energy Cost (Rp)

4. Results and Discussion

The peak load values before the implementation of the DSM and after the implementation of the DSM are shown in Table 1. In the apparent power, the peak load for the Siantan GI daily average load in 2019 before the implementation of the DSM was at a value of 32.218.89 kVA and the real power was at a value of 31,252.32 kW which occurred at the WBP at 19.00.

Table 1. Peak Load

Scenario	Peak Load Before DSM		Peak Load After DSM	
	Real Power (kW)	Imaginary Power (kVA)	Real Power (kW)	Imaginary Power (kVA)
Scenario 1	31,252.32	32,218.89	29,127.85	30,028.71
Scenario 2	31,252.32	32,218.89	30,327.85	31,265.82
Scenario 3	31,252.32	32,218.89	29,422.80	30,332.78
Scenario 4	31,252.32	32,218.89	29,875.85	30,799.85

In Table 1, it can be seen that there was a decrease in the peak load value after the implementation of the 4 DSM scenarios using the load shifting method. This is in accordance with the description of the method and the effect on the shape of the load shifting load, namely load distribution between the peak load time period (WBP) and the off-peak load time period (LWBP). The biggest decrease in peak load occurs in scenario 1.

The comparison of the graph of the average annual load before DSM is applied and after DSM scenario 1 is applied is shown in Figure 3.

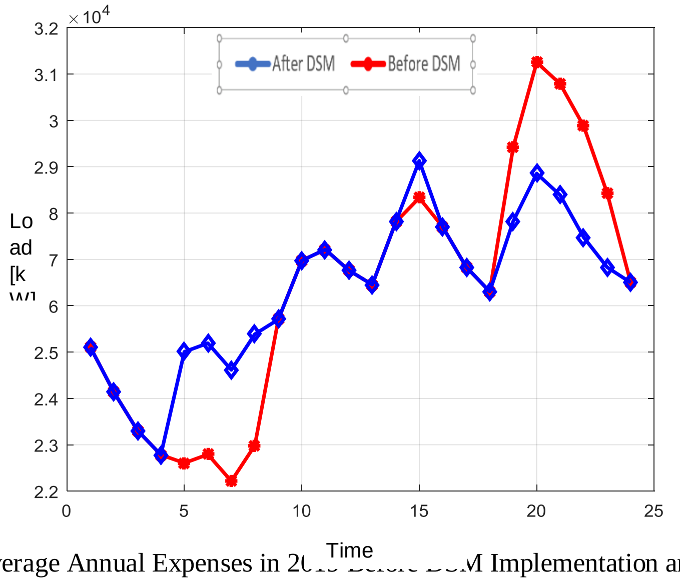

Figure 3. Graph of Average Annual Expenses in 2019 Before DSM Implementation and After DSM Implementation Scenario 1

From Figure 3, it can be seen that the peak load value before the application of DSM scenario 1 was 31,252.3 kW occurred at 19.00 and after the application of DSM scenario 1 the peak load value of 29.127.85 kW occurred at 14.00. From the graph, it can also be seen that the load smoothing from WBP to LWBP occurred after the implementation of DSM scenario 1.
The comparison of the graph of the average annual load before DSM is applied and after DSM scenario 2 is applied is shown in Figure 4.

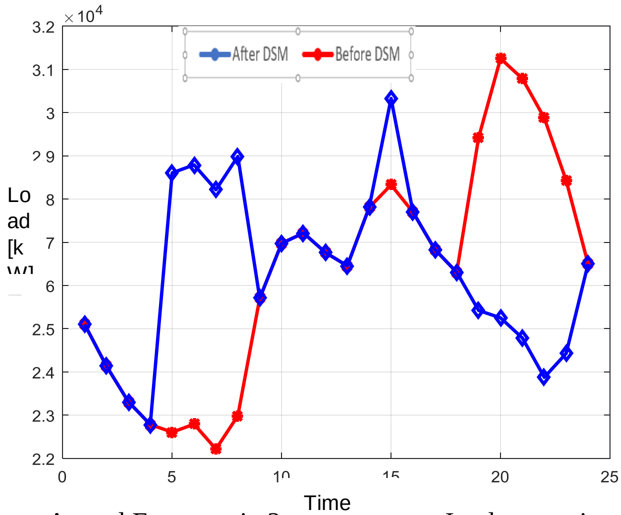

Figure 4. Graph of Average Annual Expenses in 2019 Before the Implementation of the DSM and After the Implementation of the DSM Scenario 2

From Figure 4 it can be seen that the peak load value before DSM scenario 2 was applied was 31,252.32 kW occurred at 19.00 and after the application of DSM scenario 2 the peak load value of 30,327.85 kW occurred at 14.00.

The comparison of the graph of the average annual load before DSM is applied and after DSM scenario 3 is applied is shown in Figure 5.

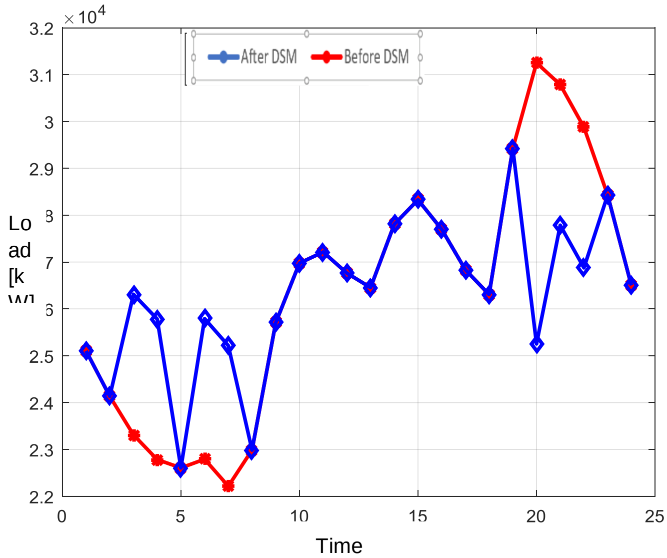

Figure 5. Graph of Average Annual Expenses Before and After Implementation of DSM Scenario 3

In Figure 5 it can be seen that after the application of scenario 3 the peak load became 29,422.80 kW which occurred at 18.00. Prior to the application of scenario 3, the peak load occurred at 19.00 at 31,252.32 kW.

The comparison of the graph of the average annual load before DSM is applied and after DSM scenario 4 is applied is shown in Figure 6.

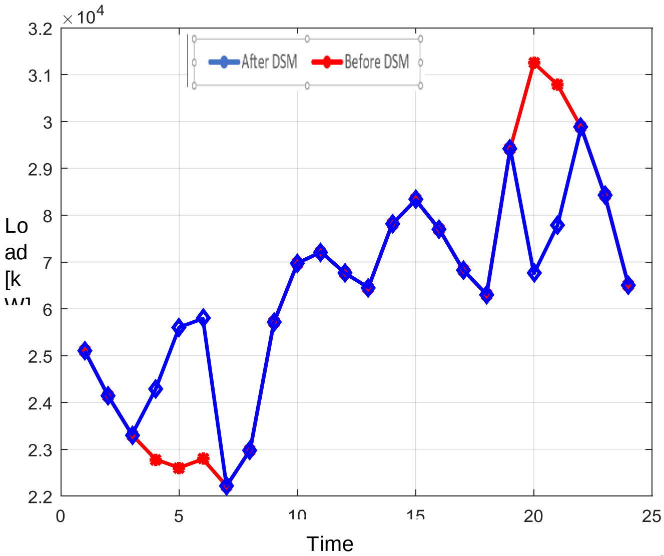

Figure 6. Graph of Average Annual Expenses in 2019 Before the Implementation of the DSM and After the Implementation of the DSM Scenario 4

In Figure 6 it can be seen that after the application of scenario 4 the peak load became 29,875.85 kW which occurred at 21.00. Prior to the application of scenario 4, the peak load occurred at 19.00 at 31,252.32 kW.
The total energy consumption of customers with the application of DSM using the load shifting method has not changed. So the average load before DSM was applied also did not change (fixed) with the average load after DSM was applied. The average load of energy consumption before and after the application of DSM is shown in Table 2.

Table 2. Average Load (P_{av})

Scenario	Load Average Before DSM (kW)	Load Average After DSM (kW)
Scenario 1	26,345.13	26,345.13
Scenario 2	26,345.13	26,345.13
Scenario 3	26,345.13	26,345.13
Scenario 4	26,345.13	26,345.13

In Table 2 it can be seen that the average load before DSM was applied was 26,345.13 kW, and the average load after DSM was applied in the four scenarios did not change, which was 26,345.13 kW.
After the implementation of the four scenarios, the result is a decrease in the peak load value (Table 1), the average load usage remains the same (Table 2), and an increase in the load factor value. The load factor values resulting from the implementation of the 4 scenarios are shown in Table 3.

Table 3. Daily Average Load Factor

Scenario	Load Factor Before DSM	Load Factor After DSM
Scenario 1	0.84	0.90
Scenario 2	0.84	0.87
Scenario 3	0.84	0.89
Scenario 4	0.84	0.88

In Table 3, it can be seen that the largest increase in the load factor value occurred in scenario 1, which was 0.90. This happens because the load factor is inversely proportional to the peak load, the lower the peak load value, the higher the load factor value, and vice versa.
With the increase in the value of the load factor, it certainly provides benefits for both the electricity company and the customer. For the electricity company itself, the higher the value of the system load factor, the more evenly the system load will be, so that the level of utilization of the existing equipment in the system can be made as high as possible. For customers, the higher the load factor value means that with the same amount of energy consumption, the billing costs can be reduced.

The reduction in customer billing costs after simulating the implementation of 4 DSM scenarios can be seen in Table 4

Table 4. Total Bill Cost

Scenario	Total Bill Before DSM (Rp)	Total Bill After DSM (Rp)
Scenario 1	496,872,926,146,792	431,646,296,366,541
Scenario 2	496,872,926,146,792	467,925,220,444,305
Scenario 3	496,872,926,146,792	440,427,615,835,722
Scenario 4	496,872,926,146,792	454,088,241,699,371

From Table 4, it can be seen that the largest difference in total billing costs between before and after DSM implementation occurs in scenario 1. This occurs because the total billing costs are proportional to the peak load value. The higher the peak load value, the greater the customer billing costs, and vice versa.
Reducing customer billing costs means there are savings to be made. Savings in customer billing costs after simulating the implementation of 4 DSM scenarios are shown in Table 5.

Table 5. Retrenchment

Scenario	Retrenchment Per Year (Rp)	Retrenchment Per Year (%)
Scenario 1	65,226,629,780,250	13.13
Scenario 2	28,947,705,702,486	5.83
Scenario 3	56,445,310,311,069	11.36
Scenario 4	42,784,684,447,420	8.61

In Table 5, it can be seen that the largest savings occurred in scenario 1, which was 13.13% and the smallest savings occurred in scenario 2, which was 5.83%. In scenario 3 there is a saving of 11.36% and in scenario 4 there is a saving of 8.61%.

IV. CONCLUSIONS

In this study it was found that the peak load value affects the load factor value and the amount of billing costs, namely the higher the peak load value, the lower the load factor value and the higher the peak load value, the greater the customer billing costs. From the 4 DSM scenarios that have been carried out, the results from scenario 1 have the best results with a load factor value of 0.90 and a savings of 13.13%. The second is scenario 3 with a load factor value of 0.89 and a savings of 11.36%. The third is scenario 4 with a load factor value of 0.88 and a savings of 8.61%. And the last is scenario 2 with a load factor value of 0.87 and a savings of 5.83%. The average annual load usage between before the application of load shifting and after the application of load shifting is the same, which is 26,345.13 kW.

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Gita Pratiwi, et. al. "Implementation of Demand Side Management At Siantan Substation for Load Factor Improvement." *The International Journal of Engineering and Science (IJES)*, 11(4), (2022): pp. 18-25.