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Time Difference Calculation Settings for Very Short Term Electric Load Forecasting Using Interval Type-1 Fuzzy Inference System (IT-1 FIS)

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Time Difference Calculation Settings for Very Short Term Electric Load Forecasting Using Interval Type-1 Fuzzy Inference System (IT-1 FIS)

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Abstract. Very short term electricity load forecasting (VSTLF) is done the day before forecasting every 30 minutes. This forecasting is imperative about the planning of operating plants, which are carried out in maintenance and related to economic considerations. This forecasting refers to the loading of electricity in a particular area and time. Very short-term electricity loading in the past few years has been used to predict the electricity load shortly. One method used for forecasting very short loads is using IT-1 FIS. In IT-1-FIS, the dataset is made by looking at the imposition of electricity on certain days at certain hours of the previous year. The data that calculate time difference forecast Friday 4th used Friday 3rd, 2nd, and 1st at the same hour and month of the past year. In this study, it proposed that the calculation of Time difference forecasting the 4th Friday be used data Thursday 4th, 4th Wednesday, 4th Tuesday. After entering into IT-1-FIS, the forecasting error result is 0,6123 %. This value is higher than if you use the time difference on Friday 3rd, 2nd, and 1st, which has a forecast error value of 0,4695 %. So it can be concluded that the time difference setting is very influential in the process of calculating forecasts, and the use of time difference data with the use of Friday data 3rd, 2nd, and 1st is better.

Keywords: Interval Type-1 Fuzzy Inference System (IT-1 FIS); Very Short Term Electric Load Forecasting; Time Difference

1. Introduction

Utilization of electrical energy should be set as well. This setting starts from generation planning and load sharing, operation, setup and other matters [1][2][3][4]. Planning is done on the load side for generation planning. This plan is also known as forecasting. The electrical load forecasting is divided into three, i.e. long-term load forecasting, short-term load forecasting and extremely short-term load forecasting[5][6]. The very short-term electrical load forecasting is required large-scale electrical systems. Forecasting of very short-term electrical burden is forecasting one day before the day of operation [7][8][9]. Forecasting is done every 30 minutes. The forecasting of this very short-term load is done by various methods. Among the methods used for forecasting a very short-term electrical load is using the Fuzzy[10][11]. The Fuzzy process required input, rule based and output. In general the Fuzzy process can be seen in the Figure 1.



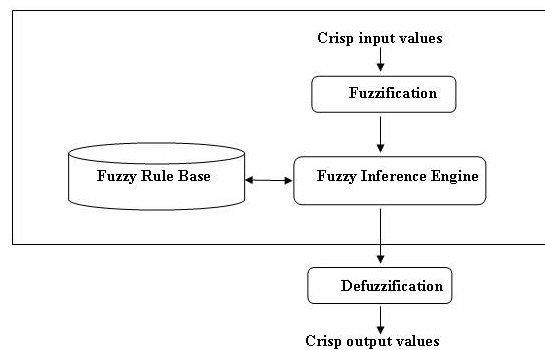


Fig.1. Fuzzy Process

Very short-term forecasting with this Fuzzy use, using data-electricity-loading data in 3 years before the year of forecast at a certain time [12][13]. In this study the analysed time was in October the 4th Friday. While the time of its ramation at out of peak load time, namely at 13.00 – 15.30 Wib. This time was chosen because it had a pretty dynamic electric load movement[14][15][16].

Inside the Fuzzy process, to define variables X, Y and Z then analysis is done – such as determinative analysis: Load Difference, Time Load Difference and Variation Load Difference [12]. In the process of determining the Load Difference, it takes time of electrical load data of the past. Data used is data 3 years ago with a time interval of 30 minutes. The analyzed time selection greatly affects the process and the results of analysis. In the previous research conducted analysis of Load Difference by using a certain month with the selection of certain days such as Friday, then the time data used is the time of the day Friday data of the week before. If the time to be in the search for an error is on Friday to 4, then the data in the analysis on Load Difference is data Friday to 3, Friday to 2 and Friday to one at the same hour[12]. It is currently proposed that the analysis is not on Friday the previous week, but on the previous day. If Friday to 4 will be searched for the value of the error, then the time data done is Thursday 4th, 4th Wednesday, 4th Tuesday.

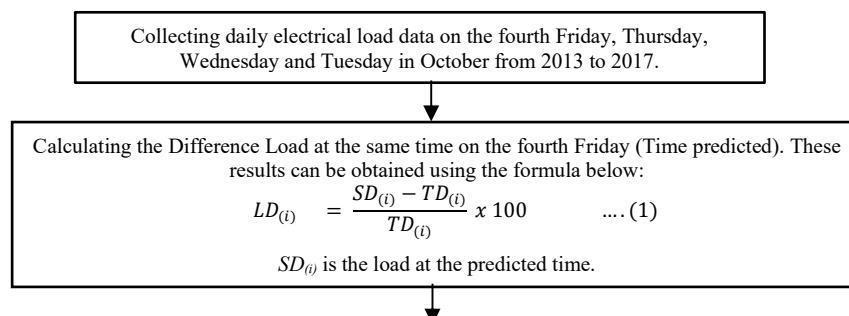
By analyzing the time different from the previous research, then it will be known to use the analysis time which has a better error value. So this result can be used for data analysis process by using Interval Type-1 Fuzzy Inference System in future research research.

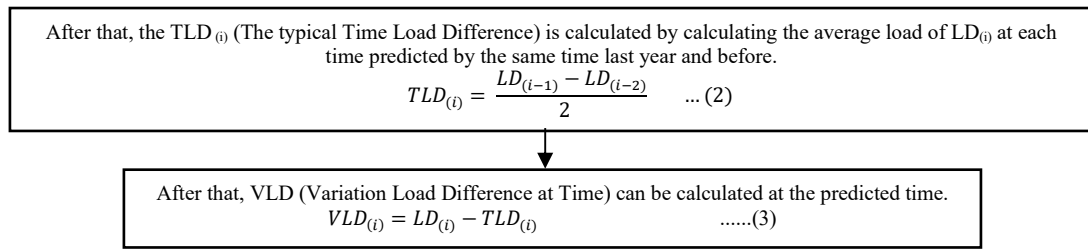
2. Material And Method

The stages of this research consist of pre-processing, processing and post-processing. The stages of the research will be explained as follows [17][12].

2.1 Pre Processing

The pre-processing stage is the preparation of daily load data every 30 minutes for 24 hours in a day, on the working day represented by Friday by classifying the out of peak load time which is at 13.00-15.30 to find the actual variation load difference, as the block diagram in Fig.2

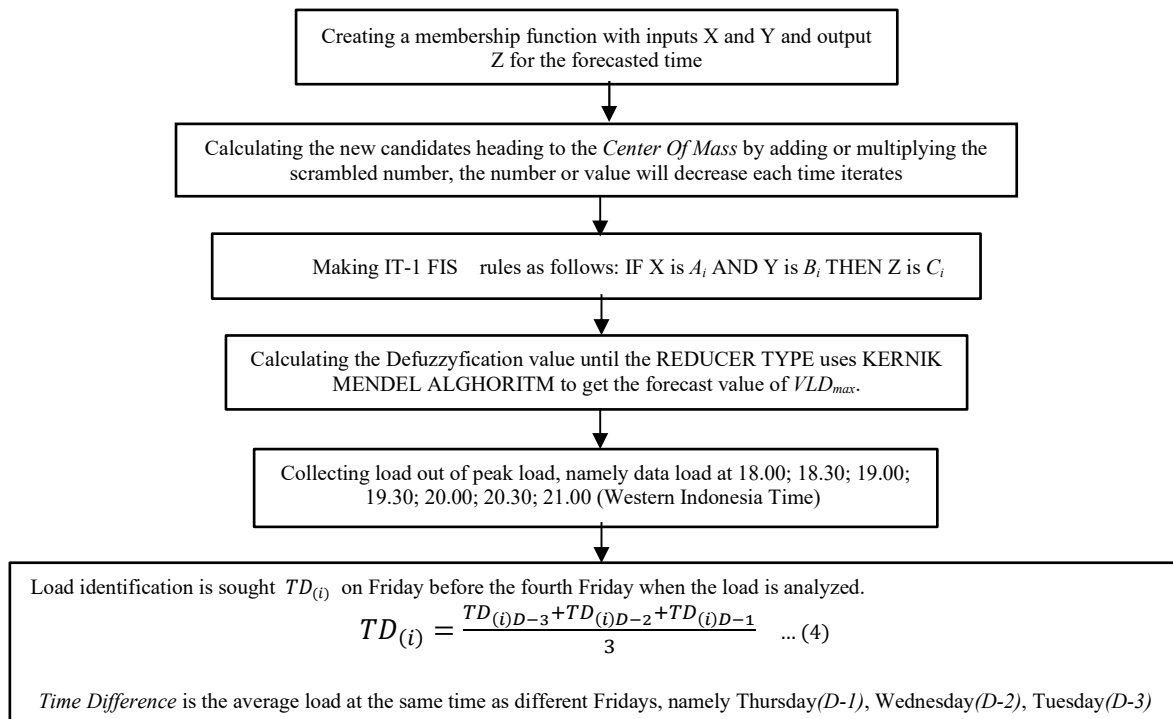


**Figure 2** Pre processing stage

2.2 Processing

In processing, the VLD value obtained from the above calculation will be entered into the IT-1 FIS, at the membership function with the following steps as Fig 3. The following input variables (X, Y) and output variables (Z) consist of 11 Fuzzy as follows :

- 1) Negative Very Big (NVB): with a range of values (ROV) of -6 s/d -4
- 2) Negative Big (NB): with (ROV) of -5 s/d -3
- 3) Negative Medium (NM): with (ROV) of -4 s/d -2
- 4) Negative Small (NS): with (ROV) of -3 s/d -1
- 5) Negative Very Small (NVS): with (ROV) of -2 s/d 0
- 6) Zero (ZE): with (ROV) of -1 s/d 1
- 7) Positive Very Small (PVS): with (ROV) of 0 s/d 2
- 8) Positive Small (PS): with (ROV) of 1 s/d 3
- 9) Positive Medium (PM): with (ROV) of 2 s/d 4
- 10) Positive Big (PB): with (ROV) of 3 s/d 5
- 11) Positive Very Big (PVB): with (ROV) of 4 s/d 6

**Figure 3** Processing stage

2.3 Post Processing

In processing, the VLD value obtained from the above calculation will be entered into the IT-1 FIS, at the membership function.. The following input variables (X, Y) and output variables (Z) consist of the membership function. After the above process, the next step is to find the error value of the VLD_{max}

forecast, done in the following ways:

Calculating the forecast value of load difference for the predicted time using Equation (5):

$$F'cast LD_{MAX}(i) = F'cast VLD_{MAX}(i) + TLD_{MAX}(i) \dots \dots (5)$$

The next step is to calculate the error value, using Equation (6):

$$Error (\%) = \frac{P_{forecast} - P_{actual}}{P_{actual}} \times 100 \dots \dots (6)$$

Where:

$P_{forecast}$ = Power predicted at a certain time (MW).

P_{actual} = Actual power at a certain time (MW).

3. Result And Discussion

The next step is to group the load in peak load conditions at each time starting in 2013, 2014, 2015, 2016 and 2017. The LD values are calculated in 2013 as in Equation (1) and (2). In the next discussion for analyzing using Third Friday, Second Friday and First Friday called by (“a” analysis). While analyzing it using Thursday; Wednesday and Tuesday call by (“b” analysis). The result can seen in Fig. 4.a. (for “a” analysis) and Fig. 4.b. (For “b” analysis).

Furthermore, for the 2015 loading year, the TD value and LD were obtained. From the electricity load data obtained in the 2015 TLD calculation value, using the Equation as shown in Equation no. (3), the 2015 TDL value is the one-year LD average value and LD value two years earlier. Whereas to get the VLD value in 2015, it is obtained by calculation as shown in Equation (4) that is from the 2015 LD value reduced by the 2015 TLD value. The results of the analysis in 2015 with can be seen in Fig.5.

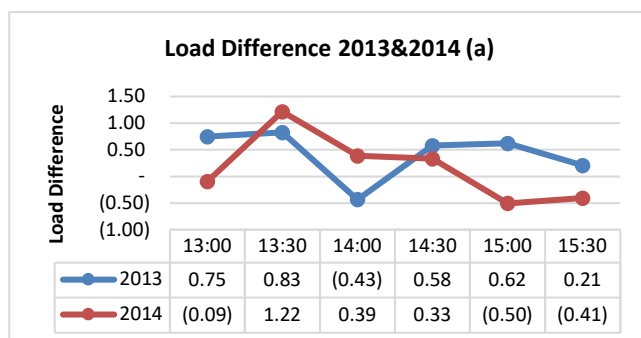


Figure 4.a. Load Difference of 2013 and 2014 (a)

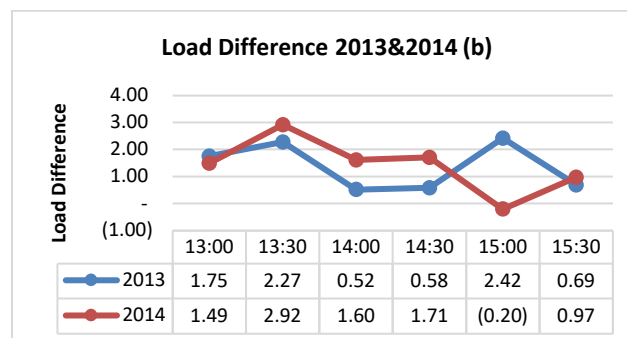


Figure 4.b. Load Difference of 2013 and 2014 (b)

For the TLD value in 2016, obtained the average value of LD 2015 and LD 2014. Whereas to get the 2016 VLD value, obtained from the 2016 LD value minus the 2016 TLD value. For the year of load calculation, 2017 TD, LD, TLD and VLD can be seen as in Fig. 5.a and 5.b.

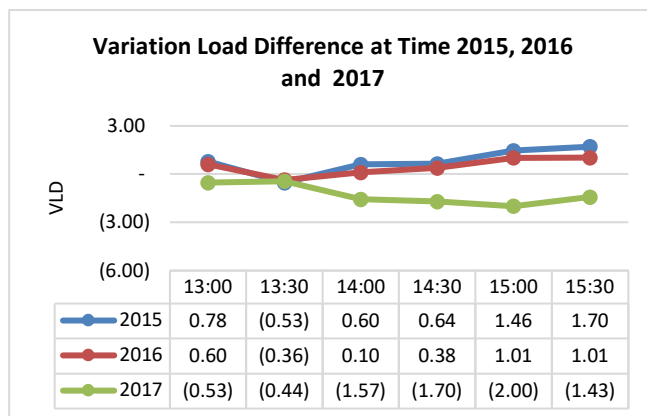


Figure 5.(a) VLD at 2015, 2016 and 2017

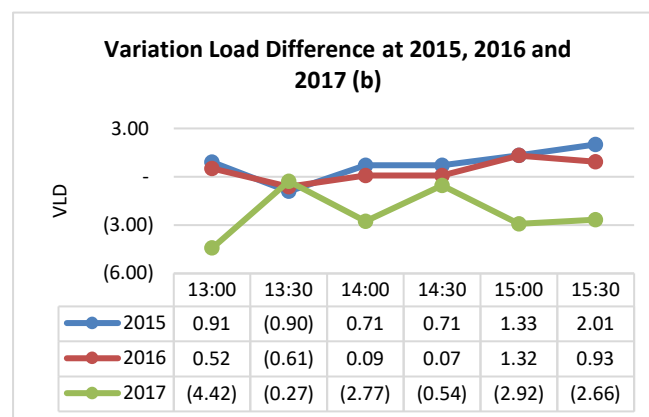


Figure 5(b) VLD at 2015, 2016 and 2017

The TLD value in 2017, obtained from the average LD 2016 and LD 2015 values. Meanwhile, the VLD 2017 value, obtained from the 2017 LD value minus the 2017 TLD value. The VLD values for 2016 and 2017, the X value of the 2016 VLD value is obtained and the output (Z) of the year VLD value is forecast in 2017, while the Y value is taken from the VLD value in 2017 for the adjacent time [18]. The result can be seen in Table 1.a and 1.b. After getting the X, Y and Z values, the next step is to enter the values into the membership function group.

Table 1.a. Calculation of determining the values of X, Y and Z

	VLD 2016	VLD 2017	X	Y	Z
13:00	0.6027	(0.5295)	0.6027	(1.4308)	(0.5295)
13:30	(0.3606)	(0.4432)	(0.3606)	(0.5295)	(0.4432)
14:00	0.0953	(1.5724)	0.0953	(0.4432)	(1.5724)
14:30	0.3826	(1.7022)	0.3826	(1.5724)	(1.7022)
15:00	1.0095	(1.9952)	1.0095	(1.7022)	(1.9952)
15:30	1.0052	(1.4308)	1.0052	(1.9952)	(1.4308)

Table 1.b. Calculation of determining the values of X, Y and Z

	VLD 2016	VLD 2017	X	Y	Z
13:00	0,522	(4,421)	0,522	(2,665)	(4,421)
13:30	(0,612)	(0,272)	(0,612)	(4,421)	(0,272)
14:00	0,086	(2,773)	0,086	(0,272)	(2,773)
14:30	0,073	(0,536)	0,073	(2,773)	(0,536)
15:00	1,319	(2,917)	1,319	(0,536)	(2,917)
15:30	0,933	(2,665)	0,933	(2,917)	(2,665)

Table 2.a. Based rule input X forecasting 2017 (a)

Time	Value X	Membership Function (μ)											Sets X
		NVB	NB	NM	NS	NVS	ZE	PVS	PS	PM	PB	PVB	
		(5)	(4)	(3)	(2)	(1)	-	1	2	3	4	5	
13:00	0.6027						0.3973	0.6027					PVS
13:30	(0.3606)					0.3606	0.6394						ZE
14:00	0.0953						0.9047	0.0953					ZE
14:30	0.3826							0.6174	0.3826				PVS
15:00	1.0095							0.9905	0.0095				PVS
15:30	1.0052							0.9948	0.0052				PVS

Table 2.a. shows that the value of X at 13.00 is 0.6027 having a positive very small (PVS) membership degree of 0.6027, while the degree of membership value of zero (ZE) is 0.3973. Once the island for another X value is treated the same as the above calculation. That calculation is the same for the Y and Z. Also for “b” analysis treated the same calculation so that the result as table 2.b.

Table 2.b. Based rule input X forecasting 2017(b)

Time	Value X	Membership Function (μ)											Sets X
		NVB	NB	NM	NS	NVS	ZE	PVS	PS	PM	PB	PVB	
		(5)	(4)	(3)	(2)	(1)	-	1	2	3	4	5	
13:00	0,5216						0,4784	0,5216					PVS
13:30	(0,6124)					0,6124	0,3876						NVS
14:00	0,0857						0,9143	0,0857					ZE
14:30	0,0726						0,9274	0,0726					ZE
15:00	1,3187							0,6813	0,3187				PVS
15:30	0,9328							0,9328	0,0672				PVS

From the data in Table 2.a. and 2.b., it is obtained the basic rules that are used to make the program in matlab, the rules are still in alphabetical form and will be changed to a number in order as in the order of the membership function above. The data can be seen in Table 3.a. and 3.b. With the conversion as in Table 3.a and 3.b., the matlab programming process can be done. Processing on matlab will generate value for VLD forecasting for 2017. After the process is done using matlab and found VLD forecasting in 2017 with the results as in Table 4.a. and 4.b. It shows very short term load forecasting in 2017 (out of peak load) fourth Friday October using IT-1 FIS.

Table 3.a. Conversion of 2017 Basic Forecasting Rules For The Matlab Software Code (“a” analysis)

No of rules	Antc		Cons		No of Rules	Antc		Cons	
	X	Y		Z		X	Y		Z
1	PVS	NVS	NVS		1	7	5	5	
2	ZE	NVS	ZE		2	6	5	6	
3	ZE	ZE	NS		3	6	6	4	
4	PVS	NS	NS		4	7	4	4	
5	PVS	NS	NS		5	7	4	4	
6	PVS	NS	NVS		6	7	4	5	

Table 3.b. Conversion of 2017 Basic Forecasting Rules For The Matlab Software Code (“b” analysis)

No of rules	Antc		Cons		No of Rules	Antc		Cons	
	X	Y		Z		X	Y		Z
1	PVS	NM	NM		1	7	3	3	
2	NVS	NB	ZE		2	5	2	6	
3	ZE	ZE	NM		3	6	6	3	
4	ZE	NM	ZE		4	6	3	6	
5	PVS	NVS	NM		5	7	5	3	
6	PVS	NM	NM		6	7	3	3	

Table 4.a. and 4.b. Results of VLD calculation in 2017 using IT-1 FIS (output matlab)

Actual VLD	Forecast VLD	Error VLD	Actual VLD	Forecast VLD	Error VLD
0,5295	(1,0185)	0,4890	(4,4214)	(1,5462)	(2,8752)
(0,4432)	(0,9582)	0,5150	(0,2723)	-	(0,2723)
(1,5724)	(1,0740)	(0,4984)	(2,7729)	(3,0000)	0,2271
(1,7022)	(0,9608)	(0,7414)	(0,5361)	(0,3859)	(0,1502)
(1,9952)	(1,5000)	(0,4952)	(2,9165)	(3,0000)	0,0835
(1,4308)	(1,5000)	0,0692	(2,6645)	(2,6515)	(0,0130)

Table 5.a. Value of 2017 forecasting and actual load expenses “a” analysis

<i>Forecast P'(MW)</i>	<i>Actual (MW)</i>	<i>Error (%)</i>
23.577,09	23.692,27	0,4861
24.618,75	24.746,13	0,5147
24.634,81	24.511,41	0,5035
24.612,72	24.430,49	0,7459
24.427,18	24.306,23	0,4976
24.316,84	24.333,66	0,0691
Sum		2,8170
Average		0,4695

Table 5.b. Value of 2017 forecasting and actual load expenses “b” analysis

<i>Forecast P'(MW)</i>	<i>Actual (MW)</i>	<i>Error (%)</i>
24.386,59	23.692,27	2,9306
24.812,57	24.746,13	0,2685
24.455,18	24.511,41	0,2294
24.466,71	24.430,49	0,1483
24.285,85	24.306,23	0,0839
24.336,83	24.333,66	0,0130
Sum		3,6736
Average		0,6123

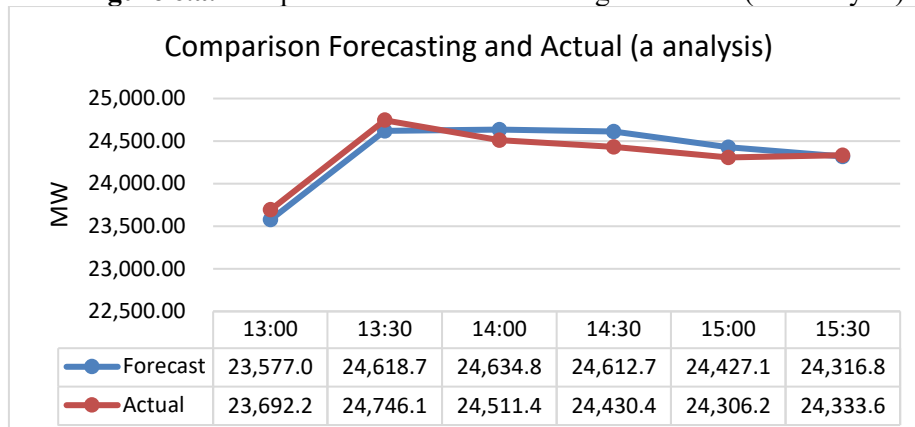
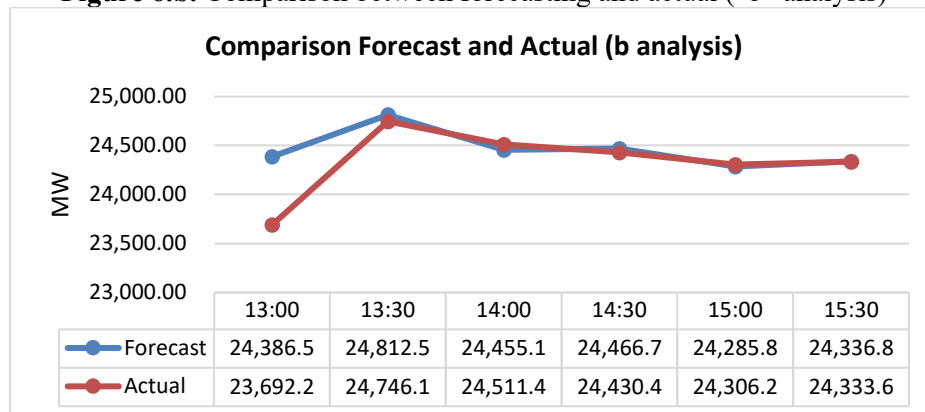
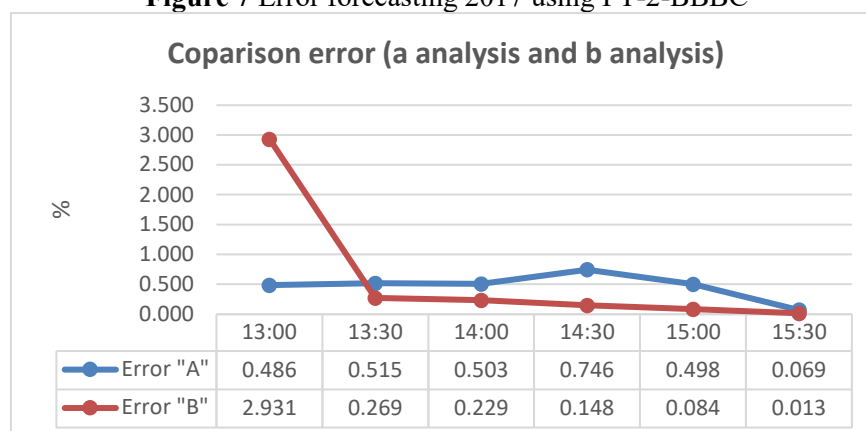
Figure 6.a. Comparison between forecasting and actual (“a” analysis)

Figure 6.b. Comparison between forecasting and actual ("b" analysis)

The value of Forecast entry to VLD electrical power calculation. The result of calculation above is show at the table 5.a and 5.b. In graphical form, it can be seen the comparison between forecasting and its behavior as in Figure 6.a. and 6.b. That's Table also shows the comparison of the value of power (P) forecasting results with the actual power (P) value. Therefore, the error value can be calculated. In Fig 7, it can be seen that the average error forecasting value using IT-1 FIS with "a" and "b" analysis.

Fig. 7 shows that comparison IT-1 FIS using ("a" analysis) and ("b" analysis). "a" analysis (Load Difference Analysis using Friday, 3rd Friday, 2nd Friday dan 1 st Friday have a small error value (0,4695). That the result show "a" analysis is better than "b" analysis for the electric load control agency in very short term load Forecasting.

Figure 7 Error forecasting 2017 using FT-2-BBBC

4. Conclusions

The findings of the research are as follows: IT-1 FIS there is a formula for managing Load Difference, the first is to use the day analyzed on the fourth Friday with data on the third Friday, the second Friday and the first Friday or called a "a" analysis. Whereas the second using the previous day, Thursday, Wednesday and Tuesday ("b" analysis). Then it can be concluded that:

1. The smaller error result is obtained from using the formula with data from the previous Friday with an error value: 0.4695%.
2. For analyzing data using IT-1-FIS several data processing formulas can be used. This can be studied further to get smaller errors.

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