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A Study on Load Pattern of Large Capacity Load Variation in the Power System

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Abstract: The purpose of this study is analysis and classified load fluctuations by the type of the power system load. The load fluctuation was appeared in case of unsatisfied the power supply and demand in the power system. It would be decreased the power quality (power system frequency) and stability in the power system. By unstable the power system, it could be occurred the wide power outage. The power system has been changed in the power capacity according to the variety load and increase transmission line capacity. This study is studied the load fluctuations by the type of the power system instability. Technical measures were used to mitigate the load fluctuation and secure the reserve power in the power system. The load fluctuation was examined by analyzing the power usage pattern of the domestic loads. It was shown the mitigation method to the most effective characteristic by the load following with the Governor Free Control (GFC) operation mode of the generator. It was operating by applying the peak mitigating type generator and the Energy Storage System (ESS).

Key words: Load fluctuation, GFC operation, reserve power, ESS, flutuation, peak

INTRODUCTION

A manage of the power system should be coincided with power supply (generation power) and demand (load power) as real time. The frequency in the power system would be raised when the power supply has been higher than the power demand. Inverse case, the frequency in the power system would be dropped when the power supply was lower than the power demand. So, the electrical energy should be adjusted to meet the generation power according to the ever-changing power demand due to difficult of mass storage. In case of sever frequency fluctuations, the power system should be stability to disturb the grid collapse and wide blackout with maintain the 60 Hz to meet the power supply and demand in real time (Lee *et al*., 2014; Radmanesh *et al*., 2013; Hyun-Chul *et al*., 2016; Lee *et al*., 2017).

Industrial loads have been occupied a less percentage than the general, commercial and residential power customers in the power system. However, the industrial load capacity has been high the share in total power market. These real-time load fluctuation of the various industrial load would be generated owing to do interaction between power system characteristic and frequency variation, voltage disturbance, etc. The power system could be connected the loads of more than 10 MW on the power transmission line. Furthermore, the 2nd industries would be accounted for large proportion in the case of domestic. In this case, the impact on power system reliability of large load fluctuations can be large than a foreign country (Gunedea, 2011).

This study is study load fluctuation in the power system by using load frequency probability analysis. The load fluctuation distribution was analyzed by the power usage pattern of domestic industrial load. In the analysis, the large demand variation was incurred by impairment of frequency fluctuations or power system stability, the rising of electricity cost. It has been analyzed that the power supply services were the intermittent load to give effect on adversely influence. The large demand fluctuations in short-term (within 15 min) has been caused on the results in a system such as frequency fluctuations or safety disturbance and rising cost of power. It would be reduced the costs associated with power system reliability for the mitigation of load fluctuation of large power consumers.

MATERIALS AND METHODS

The power system should be operating the off-peak, mid-peak and peak load. The domestic power system was shown the daily load curve in Fig. 1. The real times data was acquired 2 sec intervals in the power system. The average time was shown the 15 min intervals as average value of 2 sec intervals. The 15 min average load was calculation that the domestic reserve power.

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In order to researching the load fluctuation of the power system, it was classified by the load patterns of the load fluctuation in times as shown Table 1. It was shown by the load fluctuation calculation of the maximum and minimum value. The pattern A was shown the study in the off-peak (light level) load. Pattern B was shown study in the mid-peak (middle level) load. Pattern C and D were shown the study in the peak (high level) load.

The load pattern was compared the real-time data with the 15 min average data in Fig. 2. The trend of each power loads was different according to time. In the study between the patterns B and C, the load fluctuation was the section where the load increases and decreases, respectively (Fig. 3).

Table 1: Minimum and maximum load capacity by load pattern in the power system

Load patten	-	Max. load (MW)	Min. load (MW)	Balance load (MW)
Pattern A	Off peak load	50.233	49.464	769
Pattern B	Mid. peak load	60.042	56.894	3.148
Pattern C	Peak load	59.263	55.531	3.732
Pattern D	Peak load	59.619	58.851	768

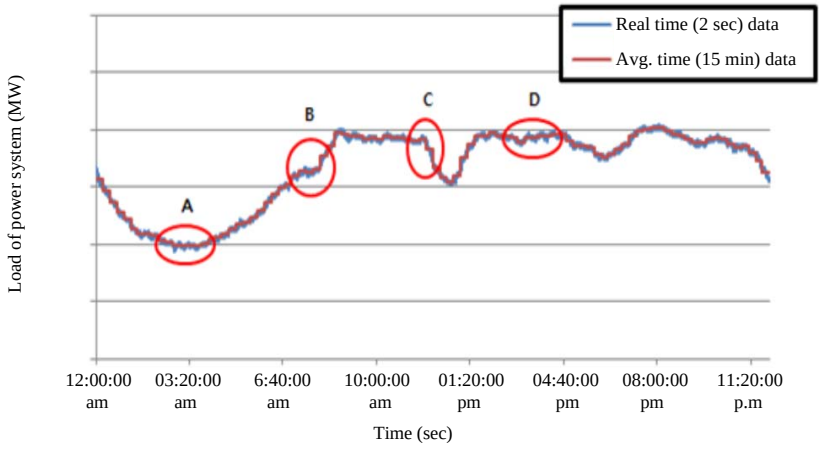


Fig. 1: Daily load curve the domestic power system. It was determined by load patterns. The patterns are shown that A is off-peak load, B is mid-peak load and pattern C, D are peak-load

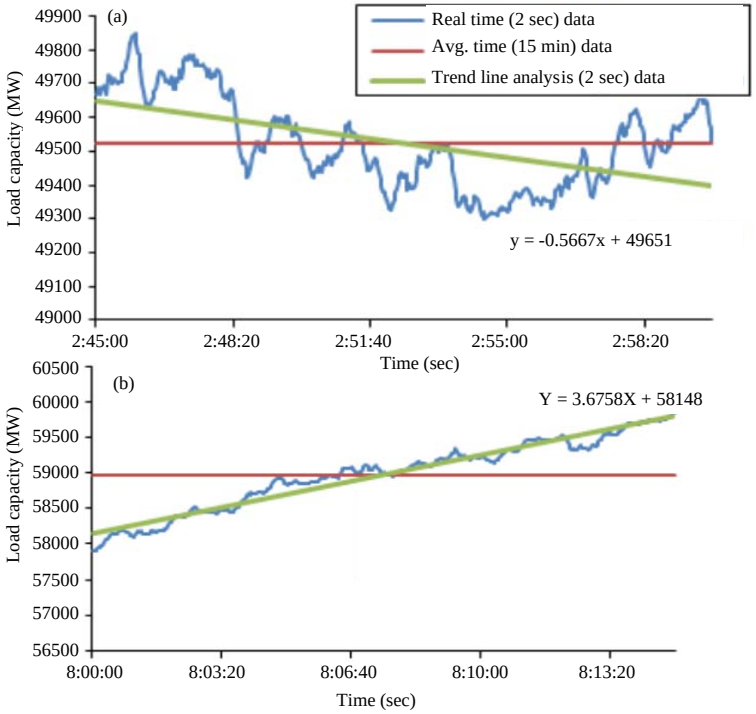


Fig. 2: Continue

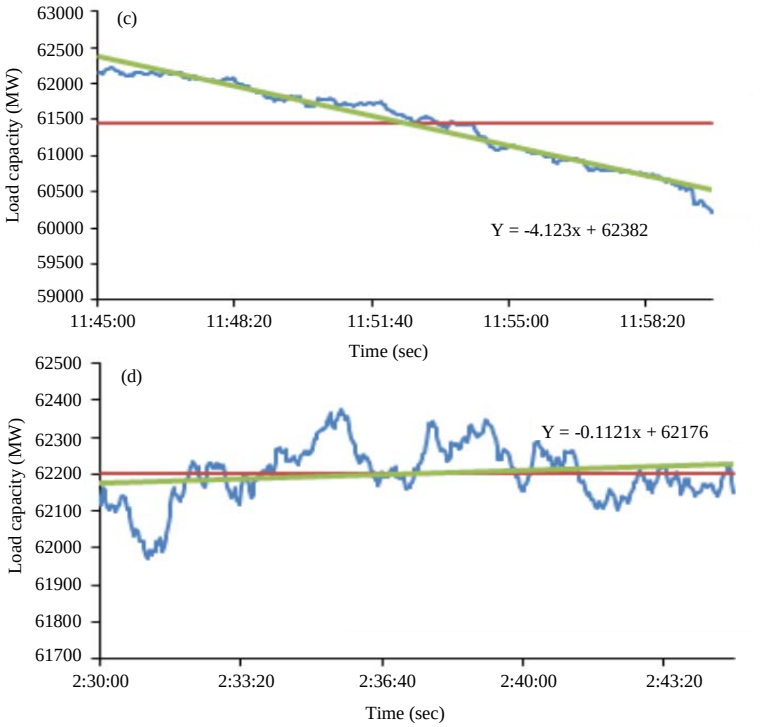
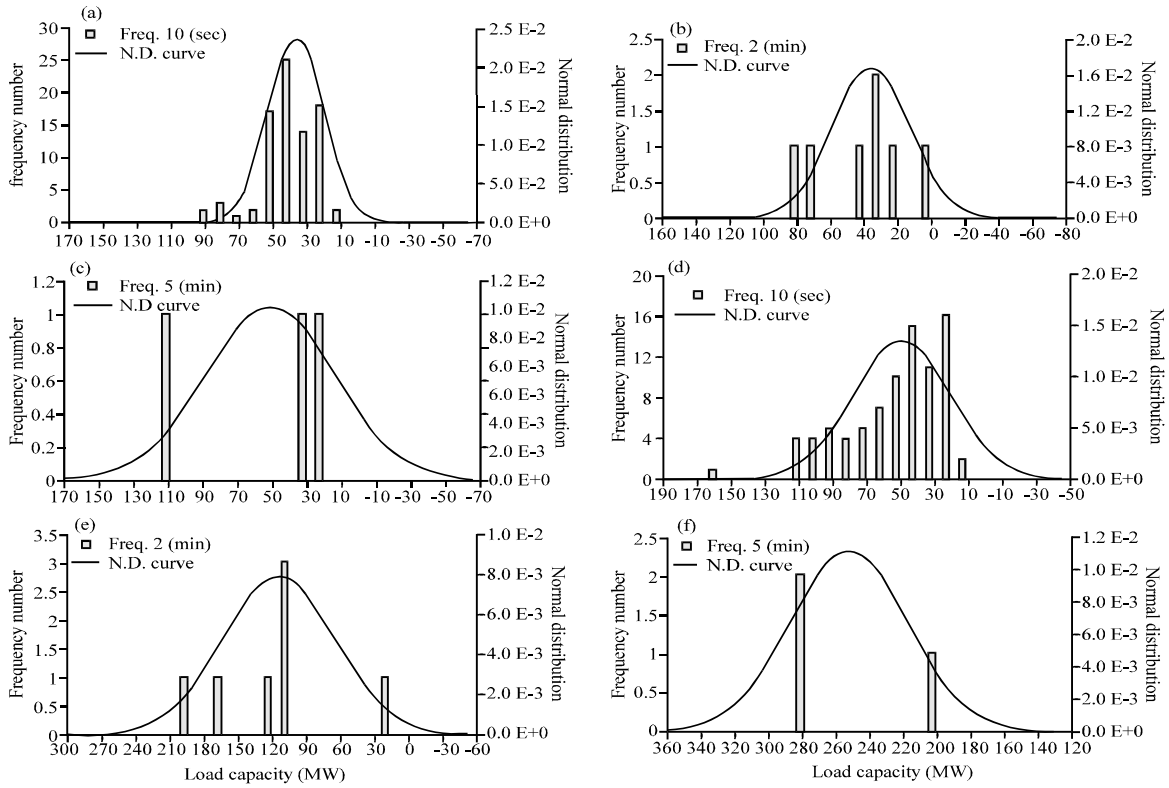


Fig. 2: Load fluctuation and average by load pattern: a) The off-peak load curve; b) The middle-peak load curve and c, d) The peak load curve



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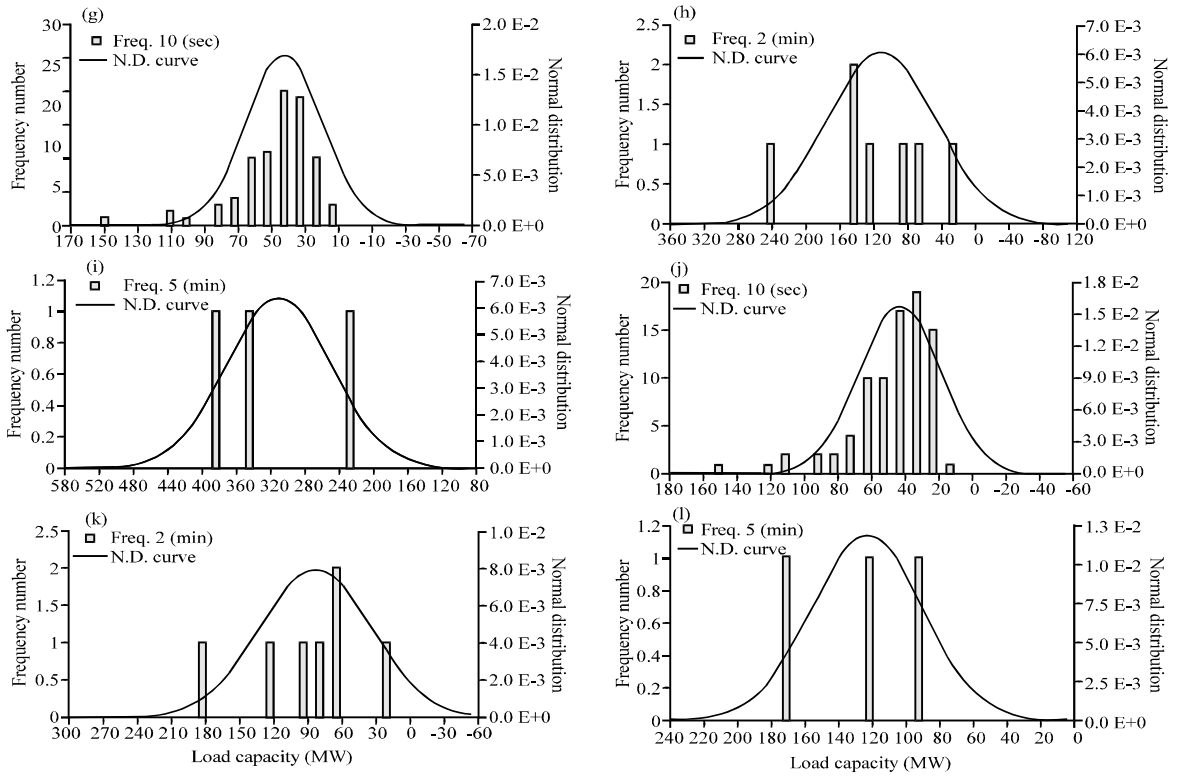

Fig. 3: Load pattern by time average in the power system. The load pattern was showing the load frequency by time average and the load capacity. Pattern A (a-c) is showed the load frequency distribution on the off-peak load. Pattern B and C (d-i) is showed the load frequency distribution on the mid-peak. The pattern D (j-l) is showed the load frequency distribution on the peak load

Table 2: Required reserve power in the load fluctuation by time

	Patten A			Patten B			Patten C			Patten D		
Reserve power (MW)	10 (sec)	2 (min)	5 (min)	10 (sec)	2 (min)	5 (min)	10 (sec)	2 (min)	5 (min)	10 (sec)	2 (min)	5 (min)
1σ (68.2%)	50~20	120~45	120~90	60~20	165~45	280	40~0	120~20	380~340	40~10	40~0	30~20
2σ (95.4%)	90~0	120~15	120~90	100~10	180~15	280~200	80~0	180~20	380~220	70~10	70~0	110~20
3σ (99.6%)	180~0	180~15	170~90	190~10	195~15	280~200	170~0	360~20	380~220	90~10	80~0	110~20

RESULTS AND DISCUSSION

The load fluctuation was the reserve power divided into σ (frequency distribution parameter of load fluctuation) distribution values by time in Fig. 3. The 10 sec average fluctuation load was needed the small capacity reserve power with high frequency for controlling GFC mode. The load fluctuation of the 1σ was shown between the maximum 60 MW and minimum 0 MW capacity loads. It was requiring large capacity reserve with low frequency in the 2, 5 min average load fluctuation for controlling Automation Generator Control (AGC) mode. The load fluctuation of the 1σ was shown between maximum 380 MW and minimum 0 MW capacity loads. By increasing the average time, the amount of the required reserve power has been increased in the load fluctuation pattern (10 sec and 2, 10 min) in the power system. However, the reserve power has been determined by the frequency of the load fluctuation in the power system. The range of generation power was shown the load pattern and frequency distribution as shown in Table 2.

CONCLUSION

The reserve power would be required to operate the power system. The reserve power capacity was calculated the load fluctuation of the large capacity load in the power system. The more reserve power would be lots of the higher the stability of the system. In the present, the power system was operating by using the average 15 min in the load. However, secured a lot of the reserve power has been increased the power production cost. So, it is necessary to appropriately distribute.

In this study, the load fluctuation was examined by analyzing the power usage pattern of domestic load. The frequency of the load was the largest in the short time average. However, the load fluctuation has been small magnitude. The long time average has been shown large magnitude. It was necessary to secure the stability by calculating the load capacity according to the load pattern.

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