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정전비용과 설비고장률을 이용한 배전계통의 설비 투자 순위평가 분석

추철민, 김재철, 문종필, 이희태
숭실대학교

A Study of the Order of Precedence Investment in Distribution System Using Interruption Cost with Facility Failure Rate

Chu Cheol Min, Kim Jae Chul, Moon Jong Fil, Lee Hee Tae
Soongsil Univ.

Abstract - Recently, it is focused on a methodology to estimate a order of precedence investment in distribution power system under competitive electricity market. This paper suggests methodology to evaluate the order as using a sensitivity of system interruption cost in distribution system regarding a failure rate of distribution components. In this paper, by using one of feeder in RBTS model, the order is assessed to compare valuation about sensitivity of interruption cost with valuation about sensitivity of estimated reliability indices. In conclusion, it is shown that results of precedence investment based on each methods are difference.

1. INTRODUCTION

In changing situation of electricity market organization, an investment planning of system facilities for customer have been important. So, the investment planning needs reasonable method considering reliability based on failure of distribution facilities. In this situation, for improving service quality of distribution system connected nearly with a customer, the investment planning can not be established without considering interruption.

Reliability that can estimate degree of interruption in distribution system is possible to use as a quantitative appraisal standard. However, It is difficult to reflect alteration of failure about an deterioration of facility. For that reason, this paper reflects the failure rate changing according to time for considering facilities' deterioration.

This paper analyzes reliability using suggested failure rate of facility. Also, this paper analyzes influence of suggested failure rate on reliability indices by sensitivity. An investment order is evaluated in order keeping proper reliability regarding to this sensitivity as influence degree of the failure rate in reliability.

Futhermore, when considering interruption, customer's distinctive quality should be considered. So, quantity of load is regarded as peculiarity of customer type. Regarding this peculiarity as factor of interruption, this paper introduce sensitivity of interruption cost about suggested failure rate.

In this paper, each method is performed to yield sensitivity of the failure rate. Also, the order of sensitivity in each method is compared which component has more influence to distribution system. Therefor, this paper show influence of load quantity as applying different load quantity in each load point.

2. Failure rate of Facility depend on time in distribution system

Many study results of fault data of each distribution facility have been presented at domestic and abroad. These results have been used for keeping proper reliability of system.

The kind of facility failure rate is two category, random failure rate and aging failure rate. The random failure rate is an accident not considered. The deteriorating failure rate is depend on time, so calculating this failure rate needs life of facility.

The failure rate that is basic parameter needed to analyze reliability of system is changed by time. So, reasonable operation planning can be effectively established, if the failure rate is considered how much the rate affect distribution system influential.

Hence, this paper produces the facility failure rate of sample model, and presents sensitivity showing influence of the facility failure rate.

2.1 Distribution of facility failure rate in Sample Model

This paper considered one of feeders in RBTS model for producing sensitivity of facility failure rate. Facilities used in this model is line, fuse and braker. In case of transformer, an average failure rate is used owing to periodical maintenance.

This paper arranged each failure rate to extract from real data. So, results of facility failure rate in sample model is as following.[4][5]

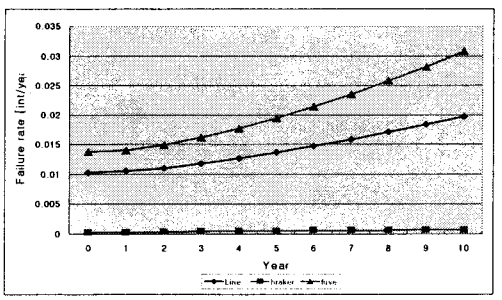

Fig 1. Failure rate Curve of Facilities in Sample Model

3. Analysis of sensitivity

The investment order is decided by sensitivity of facility failure rate. The analysis of sensitivity is to estimate how much facility failure rate affect system reliability(SAIDI, SAIFI) and interruption cost. The higher sensitivity, the more effect to the assessment indices of system. Therefore, the order of this sensitive facility should be first. The mathematical expression of this theory is as following.

$$\alpha = \left[\frac{(\text{Assessment index})_{jk} - (\text{Assessment index})_{(j-1)k}}{\lambda_{jk} - \lambda_{(j-1)k}} \right] \quad (1)$$

In equation (1), the k is a kind of facility, and the j is a appliance period of facility k.[3]

4. Case Study of Sample model

The sample model is as following Fig 2. This model consider alternative source. Also, failure rate of protective facilities is considered.[1][9]

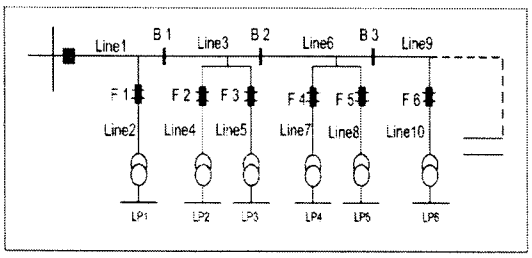

Fig 2. Sample model of Distribution System

In this model, the information that is needed for calculating the sensitivity is as following tables.

Table 1. Length of Each Line

Line Type	Line numbe	length[km]
1	2, 6, 10	0.6
2	1, 4, 7, 9	0.75
3	3, 5, 8	0.8

Table 2. Repair Time of Each Facility

component		repair time(hr)
Line	1, 3, 6, 9	4
	2, 4, 5, 7, 8, 10	1
Transformer		8
braker, fuse		0.5

Table 3. Number of Customer in Each Load Point

	Load Point					
Number of customer	1	2	3	4	5	6
	64	25	46	23	26	5

These tables represent size of sample model and interruption time owing to facility failure rate.

Table 3. Sector interruption cost in annual demand($/kW)

User sector	Interruption duration(min)				
	1	20	30	240	480
Residential	0.001	0.093	0.1819	4.914	15.69
Commercial	0.381	2.969	5.6344	31.317	83.008
Industrial	1.625	3.868	5.6344	25.163	55.808
Govt.& inst	0.044	0.369	0.6303	6.558	26.04

Table 4. Composition of load quantity in Each load point

User sector		LOAD POINT(%)					
		1	2	3	4	5	6
Residential	case 1	10	20	30	40	10	35
	case 2	40	20	10	20	40	30
Commercial	case 1	20	30	40	10	20	25
	case 2	20	20	40	30	20	30
Industrial	case 1	30	40	10	20	30	15
	case 2	20	20	40	20	10	10
Govt.& inst	case 1	40	10	20	30	40	25
	case 2	20	40	10	30	30	30

Table 3, 4 represent interruption cost depend on period and load quantity of each load point. Because the interruption cost is different depend on load quantity, this paper considered 2 case.

4.1 Results of Case Study

Using facility failure rate depend on time produce some results about reliability indices.

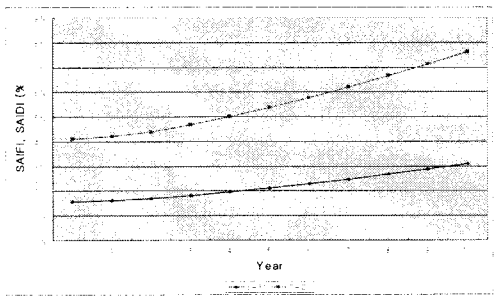

Fig 3. Change of SAIFI, SAIDI depend on failure rate

This mean is that debasement of facility should affect to system reliability. Therefor, investment order for keeping proper reliability would be invested from the most sensitive facility. Such as the investment, system operator could effectively acquire proper reliability degree by small-scale investment. Even though the scale of investment is small, the degree of reliability is satisfactorily level for customer.

However, even if operator would think that reliability level is kept satisfactory level to customer,

it is point of operator side. In oder word, SAIDI, SAIFI is system indices on operator side. Therefor, it is necessity to watch in customer' side which is target of investment. For that reason, system index connected directly with customer is interruption cost.

Assessment method of interruption cost is same method with SAIDI, SAIFI to calculate sensitivity of interruption cost about facility failure rate. After that, this result is considered to arrange from the highest sensitivity. The highest sensitivity means interruption cost is lower if the facility which have highest sensitivity would change.

For yielding these sensitivities, interruption cost is calculated by the failure rate and customer cost damage function(CCDF). These interruption costs are as following Fig 4.

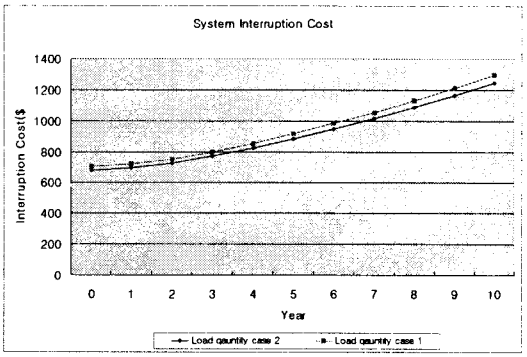

Fig 4. Increasing Interruption Cost Depend on Time

The order of investment according to sensitivity is different between sensitivity of reliability indices and sensitivity of interruption cost. Therefore, the results according to the quantity of load point is different precedence investment. This results are shown in Table 5.

Table 5. The order of precedence investment by sensitivity

SAIFI	SAIDI	interruption case 1	interruption case 2
LINE 1	LINE 1	LINE 3	LINE 3
LINE 2	LINE 3	LINE 1	LINE 6
LINE 5	LINE 6	LINE 6	LINE 9
FUSE 6	LINE 2	LINE 9	LINE 1
BRAKER 3	LINE 5	LINE 4	LINE 5
LINE 3	LINE 8	LINE 2	LINE 7
FUSE 4	LINE 4	LINE 8	LINE 4
FUSE 2	LINE 7	LINE 5	LINE 2
FUSE 5	LINE 9	LINE 10	LINE 10
BRAKER 2	FUSE 6	LINE 7	LINE 8
FUSE 3	BRAKER 3	FUSE 4	FUSE 5
BRAKER 1	FUSE 4	BRAKER 3	BRAKER 3
LINE 8	FUSE 2	FUSE 6	FUSE 6
LINE 4	FUSE 5	FUSE 3	FUSE 1
FUSE 1	BRAKER 2	BRAKER 2	FUSE 2
LINE 6	FUSE 3	FUSE 1	FUSE 4
LINE 7	BRAKER 1	FUSE 5	BRAKER 1
LINE 10	FUSE 1	BRAKER 1	BRAKER 2
LINE 9	LINE 10	FUSE 2	FUSE 3

Above mentioned, between SAIFI, SAIDI and interruption cost, are different results.

The reason, why different results computed at same failure rate depend on time, is that the considered parameter is different. In order word, the result can be different according to the considered parameter.

5. CONCLUSION

The purpose of reliability assessment is to grasp present system level. To grasp system condition is important on side of economical investment planning.

The investment of facility would lower potential accident considering composition of system. For performing this, proper level of condition is decided. In order to consider proper level of condition, reliability based on failure rate is used.

In this paper, by means of keeping level of proper reliability, sensitivity of reliability is used. Therefore, it is compared established sensitivity about SAIDI, SAIFI with the sensitivity of interruption cost.

Analyzing relation between investment order and sensitivity of the indices, maximum gains compared with investment cost is used.

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