Evaluation of Interruption Costs for Commercial Customers

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Abstract - This paper presents an evaluation of the interruption costs for commercial customers in Korea using customer survey methodology. When various research results are examined, the evaluation of direct interruption costs becomes much more simplified. Especially, in the case of commercial customers, it is known that the evaluation of direct interruption costs is more useful. Accordingly, this paper selected the customer survey method to evaluate the interruption costs for commercial customers in Korea considering interruption and customer characteristics.

Keywords: analysis of customer type, commercial customer interruption cost, customer characteristics, reliability

1. Introduction

Until recently, the decision involving the rational level of reliability was made arbitrarily based on a power company's past experience and judgment. However, along with the increase in energy prices, heightened interest in energy conservation, and governmental and environmental groups' interest in power energy, the validity of a reliability level appropriate for the operation and establishment of new power systems has become a significant issue. The legitimacy of a rational reliability level can be determined through the benefit assessment of system reliability and the evaluation of customer loss due to a decrease in system reliability level.

The quantification of loss resulting from lowered reliability can heighten the interest in the cost and value of reliability. This will play a crucial role in the planning and operation of future power systems. Even though the evaluation of value according to the different levels of system reliability is a more advanced way to fulfill this role, the evaluation of the value of reliability and interruption costs has not yet been soundly established.

The evaluation of customer interruption costs has only recently become an imperative part of research and the quantification of interruption costs is very complex and subjective. In other words, direct results of interruption are relatively easy to quantify whereas reduced labor efficiency, fear, damage, and loss of daily activities are very difficult to quantify. In addition, indirect impacts such as disorder due to interruption or business transfer to areas with high reliability are more difficult to evaluate.

Compared to direct results that have short term effect, indirect results have long term effect and therefore their evaluation is more complicated. Furthermore, the evaluation of such results depends largely on customer characteristics such as customer type, operation size, and amount of power used, as well as on power characteristics, such as interruption duration, interruption frequency and time period. Moreover, it is very complicated to calculate the interruption costs according to the reliability level the customer experienced and the one he/she expects, and the interruption costs following changes in interruption extent, i.e. extensive interruption or local interruption.

The examination of various research results indicates that the evaluation of direct interruption costs is a much simpler method. In the case of commercial customers, it is known that the evaluation of direct interruption costs is more useful.

Therefore, this paper examined the direct and short term interruption costs borne by commercial customers through a survey. The questionnaire included interruption characteristics, such as interruption duration, day, time, and month of interruption, whether an advance warning was given or not, as well as customer characteristics, such as business size and type.

2. Main Discourse

2.1 Elements examined through customer survey

A list of elements that are believed to affect the interruption costs for commercial customers was made.

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The questions were as simple as possible to minimize the inconvenience to respondents. The following items were included in the questionnaire.

(1) Interruption characteristics
- Interruption characteristics by area
- Interruption duration and frequency
- Interruption season
- Interruption day
- Interruption time
- Preference for power facility
- Worst interruption period
- Interruption cost change by period

(2) Customer characteristics
- Customer type
- Number of workers
- Average working hour per month
- Area type
- Monthly power use
- Monthly electric fee
- Loss by interruption period
- Having or not having interruption experience

2.2 Design of Questionnaire

For the survey design, a questionnaire developed by the University of Saskatchewan, Canada was adopted to suit the Korean situation.

The survey questionnaire for commercial customers developed for this paper is as follows. The questionnaires used by other researches were altered and supplemented as follows.

(1) The method to calculate the interruption costs by interruption time was improved.

(2) Items necessary for the calculation of interruption by interruption duration for commercial customers were developed.

(3) Items for the calculation of interruption costs by area and customer type were developed.

The questions used for both of the commercial customers are as follows. The questions included power use amount by area and customer type, emergency power supply device and available supply time, worst interruption month, day, and time, interruption cost change by day and month, rate of interruption cost reduction by interruption warning time, and the size and number of workers by area and customer type.

One of the most important tasks in the design of the questionnaire was to make an annual list of interruption cost changes by month, a weekly list of interruption cost changes by day and a daily list of interruption cost changes by time.

For this purpose, a Friday case was set as the base and respondents were asked about interruption cost changes. The respondents were able to record rational interruption cost changes for each question item for the base case.

2.3 Survey Procedure

The survey procedure included selection of samples by area, site visit and survey implementation, collection of power use data, and data analysis.

The power company randomly selected samples in consideration of the regional distribution of samples, visited them, and carried out the survey.

2.4 Target Areas for the Survey of Commercial Customers

800 customers were selected in consideration of regional distribution.

- Commercial customers in Seoul metropolitan area: Bundang, Suseo, and Ilsan regions (300)
- Commercial customers in metropolitan areas: Haeundae in Busan, Dalseo in Daegu, and Dunsan in Daejeon (300)
- Commercial customers in small and medium cities: Bijeon in Pyeongtaek, and Seosin (200)

2.5 Analysis of interruption characteristics

Commercial customers were classified into restaurants, large shopping centers, and small stores according to business type.

Classification was performed to calculate the interruption costs more accurately by customer type.

(1) Analysis of customer type

Table 1 indicates commercial customer type. As can be seen in Table 1, commercial customers were primarily classified into restaurants, large shopping centers, and small stores.

Table 1 Commercial customer type

No.	Customer type	Details
1	Restaurants	Regular restaurants, bars and posh restaurants, etc.
2	Large shopping centers	Department stores and large shopping centers, etc.
3	Small stores	Grocery stores, convenience stores, general stores, clothing stores, food stores, book stores, hardware stores, PC rooms, beauty salons, drug stores, furniture stores, dry cleaners, etc.

(2) Importance of electric facility and characteristics of emergency power supply device

This survey also examined the importance of various

electric facilities and the available power supply time of emergency power supply devices. Table 2 presents the results of the question concerning the significance of electric facilities for commercial customers.

(3) Opinions on interruption and safety

Most of the respondents replied as follows. As shown in Fig. 1, 53.6% of commercial customers said the number of interruptions experienced during the past year was "none". 25.9% experienced interruption that lasted over 1 hour on more than one occasion. Overall, 81.9% experienced momentary interruption, 41.0% experienced it once and 40.9% experienced it more than twice.

Table 2 Importance of electric facility

Rank	Electric facility	Average (100 points)
1	Interior lighting	85.1
2	Air conditioner	82.2
3	Exterior lighting	80.0
4	Refrigerator and cooler	78.1
5	Computer	77.8
6	Ventilator	65.4
7	Communication facility	64.9
8	Office facility	62.0
9	Elevator	60.3
10	Electric cooking facility	57.9
11	Electric cash register	57.4
12	Motor	51.6
13	Pump	51.0
14	Electric heater	48.2
15	Electric water heater	41.4

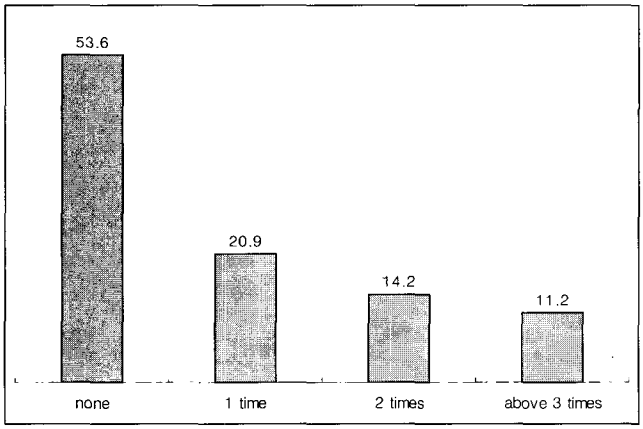

Fig. 1 Number of interruptions experienced during the past year

2.6 Methodology to Evaluate Commercial Interruption Costs by Customer Type

This clause analyzed interruption cost changes by period, and estimated interruption costs by hour and interruption costs by power use according to customer type.

(1) Analysis of interruption cost changes by period

To determine the interruption costs of worst time period and to find out its change by month, day, and time, it was assumed that an hour of interruption occurs in each period. Fig. 2 through Fig. 4 show interruption cost changes by month, day, and time for commercial customers.

In the case of commercial customers, the highest interruption costs by month occurred in August, the highest interruption costs by day occurred on Saturday, and the highest interruption costs by time period occurred between 4-5 pm.

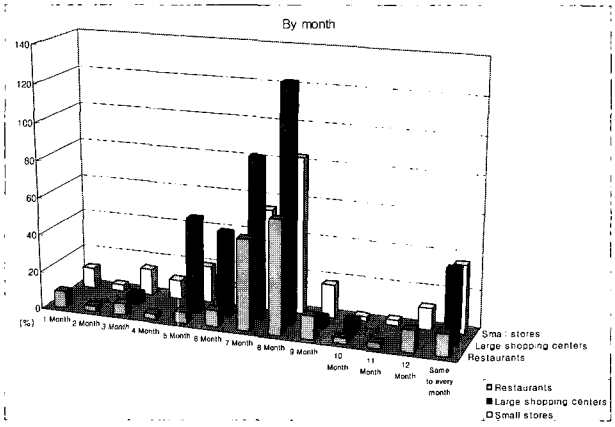

Fig. 2 Interruption cost changes by month

(2) Estimation of interruption costs by interruption duration

Each respondent answered under the assumption that interruption with unknown date and time would occur.

The respondents were asked to calculate the loss resulting from interruption for the operation of stores or organizations. Interruption costs for 1 minute, 20 minutes, 1 hour and 4 hours were examined.

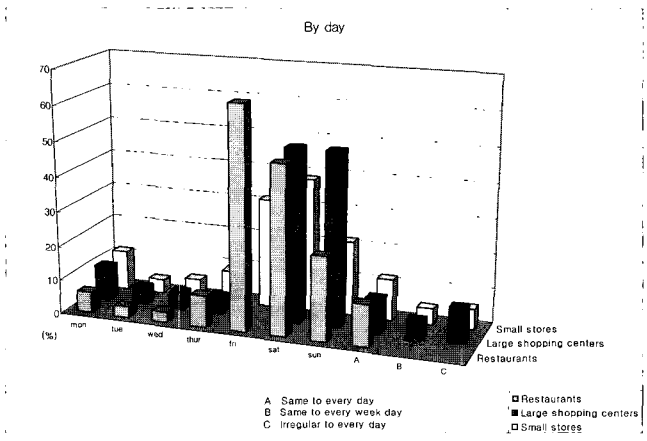

Fig. 3 Interruption cost changes by day

The respondents were asked to classify the loss into production loss, sales loss, extra labor cost, production restart cost, damage of perishable goods, and other loss. If it was difficult to divide, then the sum was requested. Table 3 indicates the interruption costs by interruption

duration and business type for commercial customers. As for commercial customers, the interruption cost was the highest for large shopping centers followed by restaurants and small stores.

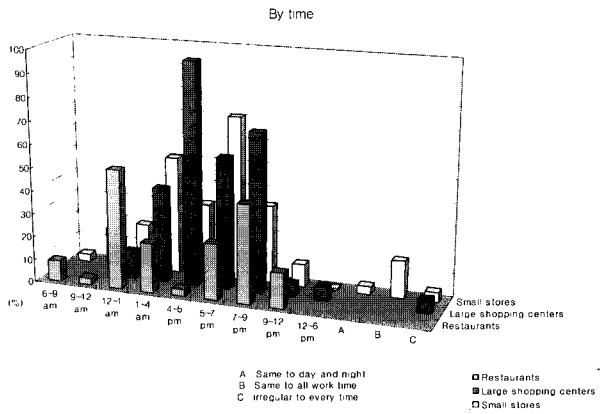

Fig. 4 Interruption cost changes by time

Table 3 Interruption costs by interruption duration and business type

Average	Interruption duration			
	1min	20min	1hour	4hour
Restaurants	6,942	13,389	41,667	166,667
Large shopping centers	8,536	17,070	43,708	204,833
Small stores	4,694	9,422	26,720	109,219

(3) Estimation of interruption cost per power use by interruption duration

Generally, methods for calculating interruption costs include both the indirect method and the direct method, with the latter being more appropriate for the calculation of interruption costs. However, in the case of residential customers, it was difficult to calculate the loss resulting from interruption directly. As a result, an indirect method of considering the amount paid for benefit (preparative action) substituting benefit (reliability) was employed.

For commercial customers, the direct estimation of interruption costs that combine direct loss according to interruption duration, such as production, sales, and extra labor costs, was used. Therefore, the estimation of customer interruption costs according to the direct loss resulting from interruption is most meaningful to commercial customers. Table 4 shows the power use by month by customer type for commercial customers.

The following assumptions were made to correct the interruption cost by interruption duration shown in Table 3 and the power use by customer type shown in Table 4.

- The statistical data of 86% provided by the Korea Electric Power Corp for 2003, was used as the daily load factor of average load against the maximum daily load for full customers.
- The maximum load time period was used for the calculation of interruption costs for commercial customers.

Table 4 Average power use of commercial customers

	Power use by month[kWh/Month]		
	Restaurants	Large shopping centers	Small stores
Average	1,476	1,325	1,296

Next, average power use and interruption cost per power use by interruption duration for commercial customers was calculated following equation 1 and equation 2 respectively.

$$Averge\ \ power\ \ use = \frac{Power\ \ use\ \ by\ \ month}{720} \quad (1)$$

$$Interruption\ \ cost\ \ by\ \ power\ \ use = \frac{Interruption\ \ cost\ \ by\ \ hour}{Average\ \ power\ use} \times Load\ \ \ factor \quad (2)$$

The result of the interruption costs per power use by interruption duration for commercial customers is presented in Table 5 through Table 7. Fig. 5 shows a comparison of the estimate of interruption costs by commercial customer type obtained by this study

Table 5 Customer Interruption costs in restaurants

	Interruption cost by hour (won)	Average Power use [kW]	Interruption cost by power use [won/kW]
1min	6,942	2.05	2,912
20min	13,889	2.05	5,827
1hour	41,667	2.05	17,480
4hour	166,667	2.05	69,919

Table 6 Customer Interruption costs in large shopping centers

	Interruption cost by hour (won)	Power use by month[kW]	Interruption cost by power use [won/kW]
1min	8,536	1.84	3,989
20min	17,070	1.84	7,977
1hour	43,708	1.84	20,426
4hour	204,833	1.84	95,723

Table 7 Customer Interruption costs in small stores

	Interruption cost by hour (won)	Power use by month[kW]	Interruption cost by power use [won/kW]
1min	4,694	1.80	2,243
20min	9,422	1.80	4,502
1hour	26,720	1.80	12,766
4hour	109,219	1.80	52,182

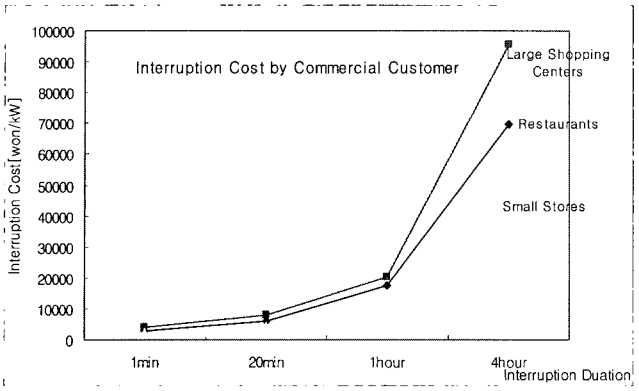

Fig. 5 Comparison of Interruption costs by customer type

3. Conclusion

This paper evaluates the interruption costs for commercial customers in Korea. While assessing customer interruption costs, the importance of the electric facility, characteristics of emergency power supply use and interruption cost changes by period were analyzed statistically.

The proposed major contents to evaluate commercial customer interruption costs are summarized as follows. First, we present a method to evaluate production, sales and extra labor costs respectively, which is incurred from interruption duration. Secondly, we present methodology to evaluate interruption costs per power use according to interruption duration by commercial customer type. To acquire this, we use interruption costs by hour, load factor and power use by month and customer type.

Through survey study, it is concluded that proposed evaluation methodology can be used to evaluate interruption costs of other customer types with the exception of residential customers.

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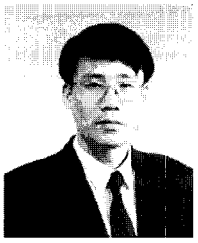

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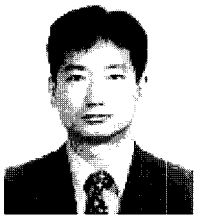

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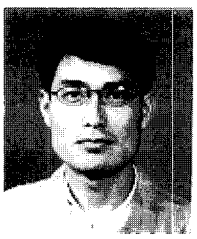

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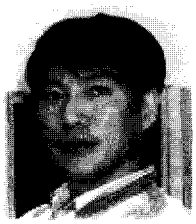

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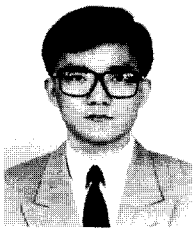

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