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Cost Assessment of Electrical Energy Interruption: A Case Study for Medium and Small Scale Industries in Indian Scenario

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Abstract

This paper presents the results of a survey conducted in the state of Uttar Pradesh in India to assess the cost of electrical energy interruption for industrial loads. In this study consumers are provided with a questionnaire which focussed on various questions regarding the cost or losses incurred by them due to frequent supply interruptions. Composite customer damage function for different industrial loads are obtained which can be related to the reliability cost/worth assessment to improve the reliability of power system for a developing country like India at a reasonable cost.

Introduction

The basic function of an electric power system is to provide electrical energy to its consumers as economically as possible and at a reasonable level of continuity and quality. A power system is said to be reliable when it satisfies the consumer load demand. Reliability has mainly two aspects; system security and system adequacy [1]. System security involves the ability of the system to respond to the disturbances arising within the system. System adequacy relates to the existence of sufficient facilities within the system. Availability of a reliable power supply at a reasonable cost is crucial for economic growth and development of a country. The rapid increase in power demand in a developing country like India is not satisfied due to limited resources, changing environment. Hence, the electric power utility has been facing problems in solving the demand crisis due to insufficient supply growth. So, the reliability cost/worth approach to system evaluation provides an opportunity for utility planners to make decisions objectively. The most appropriate approach used to assess reliability worth is to relate it with the cost or losses incurred by utility consumers as a result of supply interruptions.

A variety of methods have been utilized to estimate the impacts of electrical energy interruption on electricity consumers. The customer survey approach is the most effective and practical technique to estimate the interruption costs.

A survey has been conducted in the states of Uttar Pradesh for different industrial loads to assess the cost of electrical energy interruption for medium and small scale industries.

Questionnaire Design and Survey Methodology

A questionnaire has been prepared to collect the related data for interruption cost evaluation . A comprehensive cost of factors which might affect the cost of interruption were prepared. The questionnaire has basically

focussed the questions regarding firm's yearly output, annual value added, normal working hours, overtime pay rates, cost of raw materials etc. In addition it has been asked whether the industry has any slack productive capacity, whether they use alternative source of energy during the outage period. The future expansion plan of the industry and their requirement of load demand has also been asked.

Initially the respondents are informed about the purpose of the survey and the benefit obtained from the results of the survey. Then the relevant data are collected after discussing the related questions with the industrial consumers. 85% of the industries surveyed had been given a good response. 15% of the industries were not interested and response was found poor.

Interruption Cost Assessment

Interruption cost [2-3] can be classified into two categories, direct cost and indirect cost. Direct cost is the cost associated with the sudden supply interruption. Indirect cost arises when an interruption is expected.

Production is a process in which capital and labour are combined with other inputs such as raw materials and intermediate products to produce the desired output. The spoiled product costs for the industries surveyed are estimated. At the same time idle factor cost and overtime production costs also estimated. The industries having slack productive capacity may get a reduction in their outage cost which is known as recovered cost (RC).

80% of the industrial consumers use diesel generators to maintain production during the outage period. So, a cost is increased by the consumers which includes cost of fuel and operation and maintenance cost of diesel generators. This cost is termed as incremental cost of using alternative source of energy (ICASE). So, the total interruption cost (IC) is given by the following equation IC = (SCP + IFC – RC + ICASE).
where,

SCP = Spoiled product cost
IPC = Idle factor cost
RC = Recovered cost
ICASE = Incremental cost of using alternative source of energy.

Th cost of interruption in Rs/kwh (where kwh is the energy consumed by the consumers in a year) is presented in Table 1 and Table 2. So, the customer damage function for different types of industries are evaluated as a function of different duration's.

Table 1 Interruption cost (Rs/kwh) in 1999

Durations in hrs	Milk processing industry (Rs/kwh)	Drugs (Rs/kwh)	Printing press (Rs./kwh)	Home bread (Rs./kwh)
½	0.074	7.9	0.63	0.4
1	0.15	8.2	1.27	2.80
2	0.25	8.78	2.54	9.37
4	0.62	9.95	5.00	22.35
6	1.04	11.127	7.6	35.3
8	1.26	23.66	10.12	48.3
12	1.87	26.03	150.12	70.8

Table 2 (Continued) Interruption cost (Rs/kwh) in 1999

Duration in hrs	Fertilizer (Rs/kwh)	Steel industry (Rs./kwh)	Sports goods (Rs./kwh)
½	4.9	1.07	2.61
1	9.8	1.12	5.14
2	16.39	1.22	10.18
4	29.55	1.42	20.25
6	42.75	1.62	30.37
8	55.9	1.81	40.49
12	82.3	2.20	54.65

The interruption cost (Rs./kwh) characteristic curves (interruption costs analysis) for different industries are presented in Fig.1.

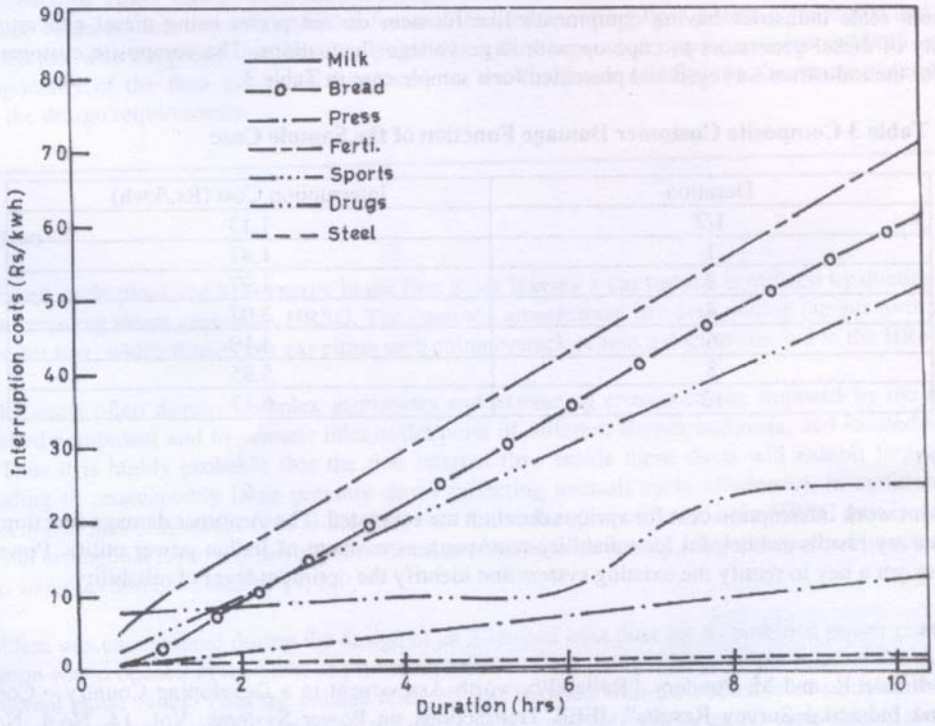

Fig. 1 Interruption Costs Analysis

Survey Results

Based on the customer damage function for different types of industries are evaluated and presented in Table I and Table 2. The following comments have been made and are briefly mentioned as follows.

1. It was verified that the average duration of an interruption, that causes damage (in terms of raw materials and finished products) is 4 hours and more than that affecting milk processing industry, drugs industry. Minimum one-day advance notice regarding the electrical power failure would minimize the interruption cost.
2. It was also noticed that 5% of the consumers are not concerned about the concept "interruption cost assessment" and this is due to the reason of small influence of interruption cost on the final cost of the product.
3. Industrial consumers were asked whether lost production can be made up once power is restored or on days following the interruption without overtime. For interruption duration more than 2 hours most respondent indicated that cost production could not be made up without overtime. But for continuous processing industries which works for 24 hours a day overtime production is not possible.
4. Some of the small scale industries such as electronic instruments manufacturing unit indicated that using diesel generators is less costly than taking supply from grid except the maintenance cost of diesel generators. Due to frequent interruption of power supply consumers have to run their standby diesel generators.

But medium scale industries having equipment's like furnaces do not prefer using diesel generators due to incapability of diesel generators to cope up with large voltage fluctuations. The composite customer damage function for the industries surveyed and presented for a sample case in Table 3.

Table 3 Composite Customer Damage Function of the Sample Case

Duration	Interruption Cost (Rs./kwh)
1/2	1.13
1	1.47
2	1.97
4	3.07
6	4.19
8	5.85
12	6.13

Conclusion

In the present work interruption cost for various duration are estimated. The customer damage function obtained from the survey results are helpful for reliability cost/worth assessment of Indian power utility. Power system planner may get a key to rectify the existing system and identify the optimum level of reliability.

References

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