Impact of Unreliable Power on a Paper Mill: A Case Study of Paper Industry of Punjab, India

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Abstract-- The availability of reliable power supply at reasonable cost is important for economic growth and development of a country. Low system reliability leads to increased outages resulting more losses to business sectors. To evaluate such losses customer survey approach was adopted as the customer is in the best judge of losses affected by the outages. The study was conducted to establish monetary losses associated with aftereffects of outages. The Customer Damage Function (CDF) approach was used in this study. The CDF value comes out to be Rs. 16.65

Index Terms:- Customer Damage Function, Interruption, Outage, Reliability

I INTRODUCTION

Electric power is an important element in any modern economy. The availability of reliable power supply at reasonable cost is important for economic growth and development of a country. Electric power utilities throughout the world therefore strive to meet the customer demands with a high quality, economic and reliable power supply. The impact of electrical power on the growth of industrialization is that the electric power in particular is considered as the key to industrialization and an engine for the growth and development. The reliability or quality of electricity supply had emerged as a key issue, because of the greater dependence of modern economies on power (Munasinghe and Sanghvi, 1988). The critical issue faced by our country is that the demand for electric power is high and the growth in supply is constrained by the technical, environmental and most importantly by financial impediments. Many power projects are cancelled or postponed due to the lack of resources. The investment burden associated with the electric power sector has already led our country into serious debt problems. In modern society, the pattern of social and working habits make mankind wholly dependent on electricity. Moreover, the society as a whole expects the electric supply to be continuously available. Electricity has great significance for people across different cultures and countries. Any interruption in the supply of electricity causes not only inconvenience but also certain tangible impacts. Productivity is the key to survive in today's globally competitive environment. Reliability and consistency of electricity supply is critical to many industrial and service activities. For the continuous process industries, an unreliable power supply not only slows down or damages production or results in shut down of plant but also leads to equipment damage, additional maintenance and the organization's reputation for the quality of product. The development over the past few years has indicated the need to improve the efficiency in the production and use of electricity and to achieve an optimum balance between the customer demands and the required investment. The significant problem of power unreliability in any industrial unit is mainly; planned or unplanned electrical interruptions. The effect of these interruptions can be quite costly to the industry and consequently to the country. The characteristics of an interruption will have a direct bearing on the consequences of an interruption and will therefore affect the cost of the interruption. If we are to understand the cost of an interruption, we need to have an understanding of the cost beyond the depth and duration. The study of impact of power interruptions is important because it can be used in a cost-benefit analysis for developing or improving the power systems. This economic analysis is fundamental to the establishment of a balance between the expenditure of obtaining a certain level of reliability and the worth of having that level.

Reliability: - The mission-oriented definition of the term reliability is "the probability of a device or system performing its purpose adequately for the period of time intended under the operating conditions encountered". Reliability as applied to power systems is a measure of the ability of the system to meet the load demand by providing an adequate supply of electrical energy. Availability is often used as one measure of reliability. Availability is defined as the percentage of time a customer is uninterrupted. Availability is considered as a subset of reliability as it only provides information about

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annual interruption duration, and not about interruption frequency.

Interruption or outage: Interruption or outage is defined as the complete loss of supply voltage or load accent. Depending on its duration, an interruption is categorized as the instantaneous, momentary or sustained. Interruptions or outage can be planned or unplanned.

Unplanned outages: If the occurrence time of the interruption has not been selected, then the interruption is unplanned. An emergency unplanned outage is a result of the loss of a section of the power network which may occur without prior indication.

Planned outages: A planned interruption occurs at a selected time less inconvenient for the customers and the customers have been notified beforehand of the interruption. A planned outage occurs when electrical lines or equipment have to be temporarily taken out of service for repair or to allow network maintenance and alterations. Unless undertaken in an emergency situation, a planned outage will be scheduled in advance, and affected customers will be made aware of the outage before it occurs. Every effort is made to undertake planned outages during the times which will create least inconvenience among customers, but in some instances this is not always possible.

Direct costs of interruption or outage: Direct costs of interruption or outage are those arising directly from the electrical interruption and relate to impacts such as lost industrial production, spoiled or damaged raw materials, loss of market, damage of equipment and machinery and loss of any form creditable to the industry.

II LITERATURE REVIEW

Electrical interruptions or poor power reliability affect almost all types of industries, commercial, residential, agricultural and other electrical power customers throughout the world due to sharp increase in power demand as compare to low increase of power generation.

Farrokhzad et al. (2004) suggested that the basic function of an electric power system is to supply electrical energy to the customers as economically as possible and with an acceptable level of reliability. In addition to equipment reliability, data collection of outage statistics associated with bulk electricity system was very important and must be collected.

Eassa et al. (2007) suggested that the one of the main tasks of each utility is to provide and supply reliable electricity to customers at reasonable prices. The prices of electricity normally vary in accordance with the level of utility's reliability standards. The outage cost was calculated using the Customer Damage Function. In respect to the effects of interruption of supply on a customer, the interruptions were classified as planned and unplanned interruptions. Outage cost model, which was developed according to electricity tariff classified customers into several categories e.g. residential, small industry, large industry, commercial, specific business and government organizations. Data used in the outage cost study had been gathered from the direct surveys and the interviews with power consumers and concerned persons in the different agencies and households.

Kjolle et al. (2008) presented in the paper the methodology and main results of the most recent Norwegian customer survey on consumer valuation of interruptions. The survey provided cost estimates for the interruptions of different duration and the cost of energy not supplied. The direct worth approach used in the study yielded significantly larger cost estimates. There has been a real increase in the customer's cost since 1991 survey for all groups and particularly for the agricultural group. The cost that an outage of electric supply creates in clients, generally refers to the energy that this same interruption has not been able to provide; this is expressed in US$ per kWh that have not been supplied.

Ghajar and Billinton (2006) suggested and found that the one of the most commonly used methods to gather electric power unreliability cost data is to survey electrical customers, sector by sector, to determine the costs or losses resulting from power interruptions. The interruption cost estimates obtained from the survey respondents vary widely for different customers and with different interruption related characteristics, such as interruption duration, frequency, time of occurrence, etc. The outage cost for a given type of customer, as a function of interruption duration, is referred to as customer damage function (CDF). Interruption cost for large users, industrial in $/kWh was $ 3.39.

Kerin et al. (2007) investigated the effects of unreliability of electrical power on organizations and industrial sites in Slovenia. The on-site approach involving questionnaire-based interviews was applied. Industrial networks in Slovenia were mainly subjected to interruptions in sum creating an annual financial impact of over 3,000,000 €.

Mabasa (2007) observed that the economy at large has been hit hard by ZESA's (Zimbabwe Electric Supply Association) erratic supply of power in Zimbabwe. A lot of production is being lost by the industries through the power cuts.

Chowdhury et al. (2009) presented a very popular method utilized in quantifying the benefit of power delivery service reliability that was used to estimate the customer monetary losses associated with power supply interruptions by collecting data with customer surveys. The major contribution of this survey was that the impact on customers with backup supply was identified.

Targosz and Manson (2007) presented the results of a study conducted by a Leonardo Power Quality Initiative team. The study sample was comprised of 62 face-to-face surveys carried out in 8 European countries. This study has investigated industrial sectors that account for 70% of the non-residential consumption of electricity and 38% of the EU 25's turnover. The cost of unreliable power for EU-25 (European Union of 25 Countries) according to this analysis has exceeded €150bn.

Kaur et al. (2004) conducted a study to estimate the cost of power system unreliability to commercial consumers in Punjab. The results of the study emphasized the relation of reliability planning and value of quality and costs of outages based on demand behaviour of commercial consumers. The optimum reliability level must match both the customer's and

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utility's requirements. A more reliable system reduces power interruptions and as a result improves productivity, revenue and growth of consumers. Improved system reliability entails added cost due to redundant power capacity, better maintenance and more reliable technologies.

Okafor and Emeka (2008) reported that the power supply to the industrial sector in Nigeria is very unreliable. Electricity goes on and off five times in an hour, has created the serious problems for manufacturing and industrial sectors. Average power outage in the industrial sector increased from 13.3 hours in January to 14.5 hours in March. In a worsening experience, the outage increased to 16.48 hours per day in June. It was on records that an irregular power supplies was one of the greatest challenges that have been facing by the industrial sector in Nigeria.

Wang et al. (2009) presented a model to quantify the impact of electric power outages on GDP to develop an economic relationship between the reliability of the electric power supply system and the cost of electric energy unserved. The average costs for providing a stable power supply were much lower than disruption costs, which was supported by recurring to the data available of Shanghai. The impact of electricity service disruption on Shanghai's GDP (Gross Domestic Product) was about 48.18 × 108 CNY. The estimated costs per kWh unserved are 1.81–10.26 CNY (Chinese Currency).

III METHODOLOGY

The impact of power interruptions was evaluated using case study method of an industrial unit The methodology widely utilized in quantifying the benefit of electric power system reliability (outage/interruptions) is to estimate the customer monetary losses associated with power supply interruptions by collecting data with customer surveys. A case study was conducted at Harisar Papers Ltd.

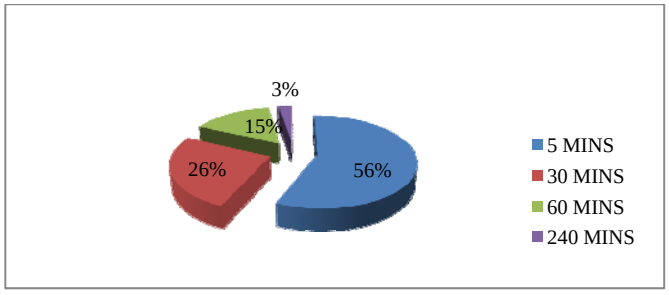

Fig. 1. Percentage of outages ranges occurred in a year

Table 2 Average numbers of outage occurred in year 2010

Outage range in minutes	No. of average outages per year
5	264
30	120
60	72
240	12
Total	468

5 minutes outage: The outage occurs without any prior notice, resulting in in-process material wastage. 20 minutes are needed to clean and again run the boiler and machine resulting in the fuel wastage for 15 minutes of. Boiler is stopped for 5 minutes in this case.

30 minutes outage: In- process material within the machine is wasted after recovery of an outage, production is regained after 2 minutes and 20 minutes are needed for boiler to achieve its working pressure and temperature resulting in 22 minutes of fuel wastage. Boiler is stopped for 30 minutes in this case and 52 minutes of production were lost, 22 minutes of boiler fuel wastage.

60 minutes outage: in this case the loss is more as compared to previous durations was of total 82 minutes of which production loss was of 60 minutes and 22 minutes of boiler fuel wastage.

240 minutes outage: in this case the loss is more as compared to all the previous durations was of total 262 minutes of which production loss was of 240 minutes and 22 minutes of boiler fuel wastage.

Table 2 Monetary values lost for the period of interruptions

Losses in Indian Rupees	Outages			
	5 min	30 min	60 min	240 min
Production	433.3	1126.6	1776.6	5676.6
Boiler fuel wastage	265.6	389.5	389.5	389.5
Labor cost for idle time	196	510	804	2570
Material wastage	100	100	100	100

Worst months of a year: It was predicted from the data that the months of March followed by February, July, August as worst period during summers and November, December and January as worst months during winters as far as weekly off days are concerned. June and July were the worst months followed by January, March, May, August, October and December as far as peak load is concerned. Worst days of the month: Industries predicted that all working days except compulsory off days are all equally worst during the period of worst months as per the schedule power cuts.

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IV. CONCLUSION

A survey of the paper mill has been performed and the result of the survey in form of customer outage costs and customer damage functions have been derived.

1. An outage loss for the concerned industry was Rs 2.45 crores.
2. The customer damage function was Rs 16.65 for the power not supplied for one hour.
3. The ratio of cost to current rate of cost per Kilowatt for Company was 3.7.
4. Outage cost per annual kWh consumption was. Rs 0.0039
5. Outage cost per kW load disconnected was Rs 12.67
6. Annual outage cost per annual kWh consumption was Rs 0.262
7. Annual outage cost per annual kWh not supplied was. Rs 0.464

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