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Economic damage caused by long length planned power outages on paper mills : a survey of three paper mills

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ABSTRACT : Considerable attention has been directed throughout the world to assess the economic consequences to electric energy customers due to unreliable power supply. Due to complexity in cost patterns of industrial sector in comparison with residential and commercial sector, a very few studies were conducted in this sector. So, three Craft paper mills of medium scale in Ludhiana (Punjab) were selected as a practical case to conduct a study considering the years 2008 and 2009. Customer survey approach was adopted because the customer is in the best position to assess the effects of interruptions or outages and thus give help to calculate associated costs more accurately. The primary purpose of conducting this survey was to establish monetary losses associated with off-days and peak load imposed by electricity board in 2008 and 2009. The number of weekly off-days and peak load was analyzed accurately through circulars available on the official website of Punjab State electricity Board. The approach called Customer Damage Function (CDF) was used in this study. It includes two terms, one that ascribes a cost to the energy not supplied in Rs/kWh and one that ascribes a cost to the load disconnected. CDF portrays the costs associated with outages as a function of outage duration.

Keywords : Unreliable power, outages/interruptions, monetary losses, customer survey, customer damage function.

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. The term reliability is used to indicate the ability of a system to continue to perform its intended function. Power-system reliability refers to availability of electric energy to all its connected customers as and when needed in a desired manner. In modern society, the pattern of social and working habits made mankind wholly dependent on electricity. Moreover, the society as a whole expects the electric supply to be continuously available. Any interruption in supply of electricity causes not only inconvenience, but also certain tangible impacts. The impact of electrical power on the growth of industrialization is that electric power in particular is considered the key to industrialization, and an engine for growth and development [1]. Reliability and consistency of electricity supply is critical to many industrial and service activities. For continuous process industries, an unreliable power supply can result in very substantial costs to the operation that includes loss in production, idle labor costs, extra restart costs, delays in delivery and reduced customer satisfaction, loss of market share. Today's Paper industry, faced by operating and energy cost increase, seeks production optimization and stability but an unreliable power supply is a major barrier to achieving this goal. The critical issue faced by our country is that the demand for electric power is high and growth in supply is constrained by various financial impediments. Many power projects are canceled or postponed due to a lack of resources.

II. METHDOLOGY

The CIGRE TF 38.06.01 Report noted that a variety of methods have been utilized to evaluate customer impacts due to interruptions. These methods can be grouped into the three broad categories of indirect analytical evaluations, case studies of blackouts, and customer surveys [3]. Results from both analytical methods and the case studies have indicated that cost assessments should obtain information that is customer specific. Customer-specific costs are the losses that various customers experience due to the unavailability of the functions, products and activities that are dependent upon power supply. The best source of this information is customers themselves. 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. Customer surveys can be conducted by e-mail, telephone/ mobile or using in-person interviews. The activity began by investigating the possibilities of using these techniques and selecting the most viable approach. E-mail surveys were not considered viable because of the fear of validation of data and poor response rates. Customer surveys by telephone are not feasible because of the detailed customer information requirements and the lack of awareness of the concept and practice. It was therefore decided to conduct survey using in-person interviews [2, 3, 4].

Researchers divided the cost incurred by consumers due to electrical interruptions into two categories (1) Direct cost and (2) indirect cost. It is not so easy or possible to find out indirect cost of interruptions, but direct cost is easier to evaluate with

more precision and accuracy. That is way direct cost method is utilized in present study to find out the monetary losses incurred by Paper mills. Direct Cost is the cost which is process based and can be evaluated directly such as material costs, manpower costs, fuel costs, market costs and lost production costs.

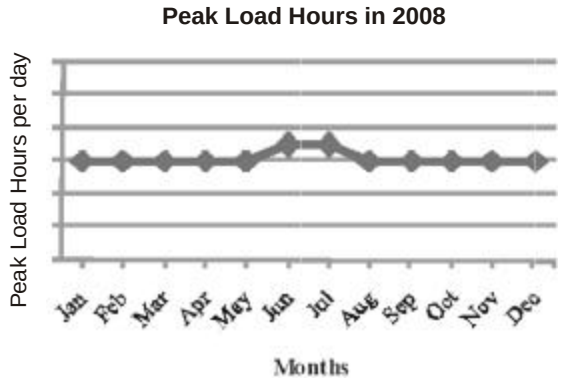
A useful data that relates to cost and other processes were extracted through conversation with an industrial person. The general data that was collected during conversation, then extrapolated and interpolated to get the useful observations. These observations were then used to estimate the cost and savings of each individual parameter that was affected during outage of different durations. Indirect costs are not evaluated in the study.

Following direct costs are included in the study for carrying out the survey and the direct costs that were evaluated are given below:

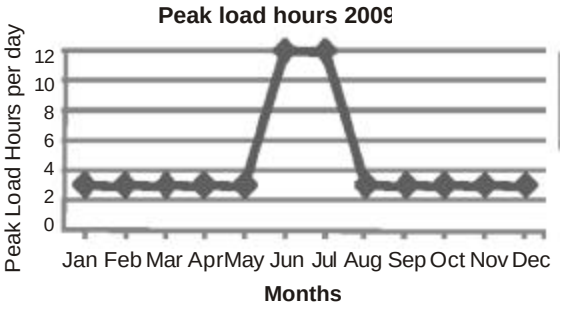
1. Loss in production
2. Cost of Idle Manpower
3. Cost of running backup generator
4. Cost of boiler fuel wastage
5. Cost of Market value

The information regarding the off-days and peak load was collected from circulars available on P.S.E.B official website for the years 2008 and 2009. A critical analysis of these circulars was done in order to find out the actual number of weekly off days of different durations for both the years under consideration. The on-load current measurements for all the electric motors used in paper mills were taken with the help of clamp on ammeter in order to find out the energy consumed by each machine in kWh. These measurements were needed to calculate the machine savings for particular outage duration. The approach called Customer Damage Function (CDF) was used in this study. Customer damage functions are useful for reliability planning in several ways. First, the customer damage function provides a framework for conceptualizing and estimating the factors that influence customers' outage costs for particular types of outages. Second, the use of a customer damage function allows for analysis of the isolated effects of different attributes of outages such as duration or time of day. Third, it can be used to quantify the economic losses from different electricity system reliability investments by multiplying appropriately defined customer damage functions by the un-served energy expected under different system investment options. These calculations then become the basis for comparing different reliability solutions and evaluating whether the economic benefits to customers are justified by the costs of the investment options. It includes various terms such as Cost of energy not supplied in Rs/kWh energy not supplied, Cost of load disconnected in Rs/kW load disconnected, Cost of specific outage per annual kWh energy consumption, Ratio of annual outage cost per annual kWh energy consumption and ratio of annual outage cost per annual kWh energy not supplied and Ratio of cost to current rate of cost per kilowatt [5, 6].

III. RESULTS AND DISCUSSIONS



(*a*)



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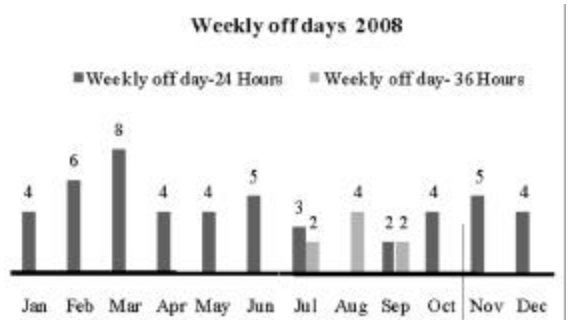

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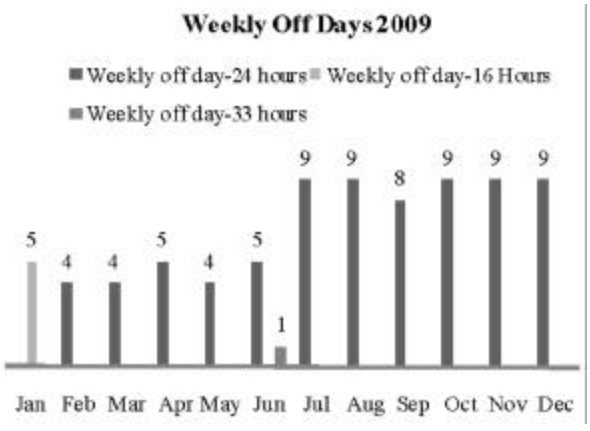

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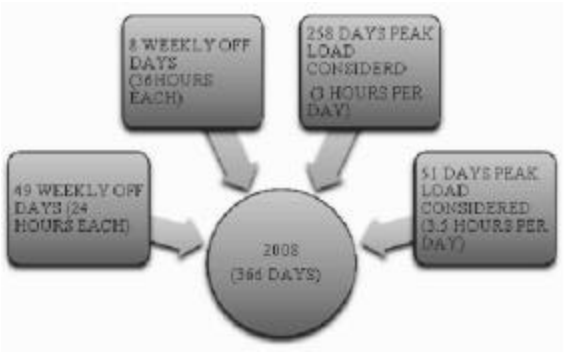

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Fig. 1. (a) and (b) shows the peak load hours per day in each month occurred in 2008 and 2009. (c) and (d) represents the number of weekly off days per month. (e) and (f) represents the summarised data regarding off days and peak load.

Table 1 : (a) Shows the elements of costs and savings and total loss is calculated for different outage duration.

HARISAR PAPERS LTD. (WEEKLY OFF DAYS)									
LOSSES		24 HOURS		36 HOURS		33 HOURS		16 HOURS	
		2008	2009	2008	2009	2008	2009	2008	2009
1	PRODUCTION LOSS	407978.18	412358.31	611402.18	617966.31	560546.17	566564.31	272362.00	275286.30
2	BOILER FUEL WASTAGE	973.96	973.96	973.96	973.96	973.96	973.96	973.96	973.96
3	SALARIES PAID TO IDLE STAFF	14145.42	14180.10	21198.54	21250.48	19435.30	19482.88	9443.34	9466.48
4	DIESEL CONSUMPTION IN GENERATOR	125.24	133.32	125.24	133.32	125.24	133.32	125.24	133.32
	SAVINGS	24 HOURS		36 HOURS		33 HOURS		16 HOURS	
		2008	2009	2008	2009	2008	2009	2008	2009
1	NO WEAR AND TEAR OF FELT, WIRE, SCREEN	7821.67	7821.67	11721.67	11721.67	10746.67	10746.67	5221.67	5221.67
2	RAW MATERIAL NOT USED	305403.55	305403.55	457893.55	457893.55	419771.05	419771.05	203743.55	203743.55
3	BOILER FUEL NOT USED	62953.12	62953.12	94828.12	94828.12	86859.38	86859.38	41703.13	41703.13
4	ENERGY SAVINGS	40556.00	45062.50	60806.25	67562.50	55743.75	61937.50	27056.25	30062.50
5	CHEMICALS NOT USED	3133.48	3133.48	4695.88	4695.88	4305.28	4305.28	2091.88	2091.88
NET LOSS		3554.98	3271.37	3754.45	3622.40	3654.55	3534.57	3088.00	3037.40
MARKET VALUE OF PAPER		76965.39	72584.69	115341.21	108777.08	105747.22	99729.08	51381.39	48457.09
TOTAL LOSS		80520.37	75856.06	119095.70	112399.50	109401.80	103263.60	54469.39	51494.49

Table 1 : (b) Quantitative and Monetary values of elements wasted and saved due to outages of different duration.

HARISAR PAPERS LTD.		WEEKLY OFF-DAY DURATION							
LOSSES		24 HOURS		36 HOURS		33 HOURS		16 HOURS	
		2008	2009	2008	2009	2008	2009	2008	2009
1	PRODUCTION LOSS @ 1300 Kg/hr	31286.67	31286.67	46886.67	46886.67	42986.67	42986.67	20886.67	20886.67
2	BOILER FUEL WASTAGE @ 1062.5 Kg/hr (Rice Husk),Kg	389.58	389.58	389.58	389.58	389.58	389.58	389.58	389.58
3	SALARIES PAID TO IDLE STAFF @ Rs 587.43/hr (2008) & Rs 589/hr (2009)	14145.42	14180.10	21198.54	21250.48	19435.30	19482.88	9443.34	9466.48
4	DIESEL CONSUMPTION, LITRES	4.04	4.04	4.04	4.04	4.04	4.04	4.04	4.04
SAVINGS		24 HOURS		36 HOURS		33 HOURS		16 HOURS	
		2008	2009	2008	2009	2008	2009	2008	2009
1	NO WEAR AND TEAR OF FELT, WIRE, SCREEN @ Rs 0.25/Kg of finished paper	7821.67	7821.67	11721.67	11721.67	10746.67	10746.67	5221.67	5221.67
2	RAW MATERIAL NOT USED @1495 Kg/hr	35929.83	35929.33	53869.83	53869.83	49384.83	49384.83	23969.83	23969.83
3	BOILER FUEL NOT USED @ 1062.5 Kg/hr (Rice Husk)	25181.25	25181.25	37931.25	37931.25	34743.75	34743.75	16681.25	16681.25
4	ENERGY SAVINGS @ 375 kWh per hour	9012.50	9012.50	13512.50	13512.50	12387.50	12387.50	6012.50	6012.50
5	CHEMICALS NOT USED @ Rs 0.10/Kg of paper	3133.38	3133.38	4695.88	4695.88	4305.24	4305.28	2091.88	2091.88

Table 2 : (a) Shows the elements of costs and savings and total loss is calculated for different outage duration.

H.B PAPERS PVT. LTD. (WEEKLY OFF DAYS)									
LOSSES		24 HOURS		36 HOURS		33 HOURS		16 HOURS	
		2008	2009	2008	2009	2008	2009	2008	2009
1	PRODUCTION LOSS	332120.05	336933.38	497420.05	504933.38	456320.05	462933.38	221720.05	224933.38
2	BOILER FUEL WASTAGE	973.96	973.96	973.96	973.96	973.96	973.96	973.96	973.96
3	SALARIES PAID TO IDLE STAFF	8216.36	8245.24	12313.16	12356.44	11288.96	11328.64	5485.16	5504.44
4	DIESEL CONSUMPTION IN GENERATOR	125.24	133.32	125.24	133.32	125.24	133.32	125.24	133.32
SAVINGS		24 HOURS		36 HOURS		33 HOURS		16 HOURS	
		2008	2009	2008	2009	2008	2009	2008	2009
1	NO WEAR AND TEAR OF FELT, WIRE, SCREEN	4813.33	4813.00	7213.33	7213.33	6613.33	6613.33	3213.33	3213.33
2	RAW MATERIAL NOT USED	234925.80	234925.80	352225.80	352225.80	322900.80	322900.80	156725.80	156725.80
3	BOILER FUEL NOT USED	62953.12	62953.12	94828.12	94828.12	86859.37	86859.37	41703.13	41703.13
4	ENERGY SAVINGS	39063.78	43404.20	58568.58	65076.20	53692.38	59658.20	26060.58	28956.20
5	CHEMICALS NOT USED	2411.50	2411.50	3613.88	3613.88	3313.28	3313.28	1609.88	1609.88
NET LOSS		-2731.90	-2221.70	-5617.30	-4560.20	-4671.00	-3975.70	-1008.30	-663.20
MARKET VALUE OF PAPER		40913.34	36100.01	61613.34	54100.01	56213.34	49600.01	27313.34	24100.01
TOTAL LOSS		38181.44	33878.31	55996.04	49539.81	51542.34	45624.31	26305.04	23436.81

Table 2 : (b) Quantitative and Monetary values of elements wasted and saved due to outages of different duration.

H.B PAPERS PVT. LTD.		WEEKLY OFF-DAY DURATION							
LOSSES		24 HOURS		36 HOURS		33 HOURS		16 HOURS	
		2008	2009	2008	2009	2008	2009	2008	2009
1	PRODUCTION LOSS @ 1000 Kg/hr	24066.67	24066.67	36066.67	36066.67	33066.67	33066.67	16066.67	16066.67
2	BOILER FUEL WASTAGE @ 1062.5 Kg/hr (Rice Husk)	389.58	389.58	389.58	389.58	389.58	389.58	389.58	389.58
3	SALARIES PAID TO IDLE STAFF @ Rs341.53/hr (2008) & Rs 342.43/hr (2009)	8216.36	8245.24	12313.16	12356.44	11288.96	11328.64	5485.16	5504.44
4	DIESEL CONSUMPTION (PLANNED)	4.04	4.04	4.04	4.04	4.04	4.04	4.04	4.04
SAVINGS		24 HOURS		36 HOURS		33 HOURS		16 HOURS	
		2008	2009	2008	2009	2008	2009	2008	2009
1	NO WEAR AND TEAR OF FELT, WIRE, SCREEN @ Rs 0.20/Kg of finished paper	4813.33	4813.33	7213.33	7213.33	6613.33	6613.33	3213.33	3213.33
2	RAW MATERIAL NOT USED @ 1150 Kg/hr	27638.33	27638.33	41438.33	41438.33	37988.33	37988.33	18438.33	18438.33
3	BOILER FUEL NOT USED @ 1062.5 Kg/hr (Rice Husk)	25181.25	25181.25	37931.25	37931.25	34743.75	34743.75	16681.25	16681.25
4	ENERGY SAVINGS @ 361 kWh per hour	8680.84	8680.84	13015.24	13015.24	11931.64	11931.64	5791.24	5791.24
5	CHEMICALS NOT USED @ Rs 0.10/Kg of paper	2411.50	2411.50	3613.88	3613.88	3313.28	3313.28	1609.88	1609.88

Table 3 : (a) Shows the elements of costs and savings and total loss is calculated for different outage duration.

CHAMPION PAPER MILL (WEEKLY OFF DAYS)									
LOSSES		24 HOURS		36 HOURS		33 HOURS		16 HOURS	
		2008	2009	2008	2009	2008	2009	2008	2009
1	PRODUCTION LOSS	284395.80	288511.20	426199.80	432367.20	390748.00	396403.20	189859.80	192607.20
2	BOILER FUEL WASTAGE	435.38	435.38	435.38	435.38	435.38	435.38	435.38	435.38
3	SALARIES PAID TO IDLE STAFF	6570.20	6584.64	9846.20	9867.00	9027.20	9047.04	4386.20	4395.84
4	DIESEL CONSUMPTION IN GENERATOR	81.53	86.79	81.53	86.79	81.53	86.79	81.53	86.79
SAVINGS		24 HOURS		36 HOURS		33 HOURS		16 HOURS	
		2008	2009	2008	2009	2008	2009	2008	2009
1	NO WEAR AND TEAR OF FELT, WIRE, SCREEN	3249.00	3249.00	4869.00	4869.00	4464.00	4464.00	2169.00	2169.00
2	RAW MATERIAL NOT USED	211433.25	211433.25	317003.25	317003.25	290610.75	290610.75	141053.25	141053.25
3	BOILER FUEL NOT USED	41475.88	41475.88	62373.45	62373.45	57149.06	57149.06	27544.10	27544.10
4	ENERGY SAVINGS	37636.20	41818.00	56428.00	62698.00	51730.20	57478.00	25108.20	27898.00
5	CHEMICALS NOT USED	2166.00	2166.00	3246.00	3246.00	2976.00	2976.00	1446.00	1446.00
NET LOSS		-4477.40	-4524.10	-7356.80	-7433.30	-6637.90	-6705.40	-2557.70	-2585.20
MARKET VALUE OF PAPER		51334.20	47218.80	76930.20	70762.80	70531.20	64876.80	34270.20	31522.80
TOTAL LOSS		46856.80	42694.70	69573.40	63329.50	63893.30	58171.40	31712.50	28937.60

Table 3 : (b) Quantitative and Monetary values of elements wasted and saved due to outages of different duration.

CHAMPION PAPER MILL		WEEKLY OFF-DAY DURATION							
LOSSES		24 HOURS		36 HOURS		33 HOURS		16 HOURS	
		2008	2009	2008	2009	2008	2009	2008	2009
1	PRODUCTION LOSS @ 900 Kg/hr	21660.00	21660.00	32460.00	32460.00	29760.00	29760.00	14460.00	14460.00
2	BOILER FUEL WASTAGE @ 241.87 Kg/hr (Pet Coke)	60.47	60.47	60.47	60.47	60.47	60.47	60.47	60.47
3	SALARIES PAID TO IDLE STAFF @ Rs 273.22/hr (2008) & Rs 273.94/hr (2009)	6570.20	6584.64	9846.20	9867.84	9027.20	9047.04	4386.20	4395.84
4	DIESEL CONSUMPTION, LITRES	2.63	2.63	2.63	2.63	2.63	2.63	2.63	2.63
SAVINGS		24 HOURS		36 HOURS		33 HOURS		16 HOURS	
		2008	2009	2008	2009	2008	2009	2008	2009
1	NO WEAR AND TEAR OF FELT, WIRE, SCREEN @ Rs 0.15/Kg of finished paper	3249.00	3249.00	4869.00	4869.00	4464.00	4464.00	2169.00	2169.00
2	RAW MATERIAL NOT USED @1035 Kg/hr	24874.50	24874.50	37294.50	37294.50	34189.50	34189.50	16594.50	16594.50
3	BOILER FUEL NOT USED @ 241.87 Kg/hr (Pet Coke)	5760.54	5760.54	8662.98	8662.98	7937.37	7937.37	3825.57	3825.57
4	ENERGY SAVINGS @ 348 kWh per hour	8363.60	8363.60	12539.60	12539.60	11495.60	11495.60	5579.60	5579.60
5	CHEMICALS NOT USED @ Rs 0.10/Kg of paper	2166.00	2166.00	3246.00	3246.00	2976.00	2976.00	1446.00	1446.00

Table 4: (a) Shows the elements of costs and savings and total loss is calculated for different outage duration.

HARISAR PAPERS LTD. (PEAK LOAD)							
LOSSES		3 HOURS		3.5 HOURS		12 HOURS	
		2008	2009	2008	2009	2008	2009
1	PRODUCTION LOSS	51986.18	52544.31	60462.18	61111.31	204554.18	206750.31
2	BOILER FUEL WASTAGE	973.96	973.96	973.96	973.96	973.96	973.96
3	SALARIES PAID TO IDLE STAFF	1802.46	1806.88	2096.34	2101.48	7092.30	7109.68
4	DIESEL CONSUMPTION IN GENERATOR	125.24	133.32	125.24	133.32	125.24	133.32
SAVINGS		3 HOURS		3.5 HOURS		12 HOURS	
		2008	2009	2008	2009	2008	2009
1	NO WEAR AND TEAR OF FELT, WIRE, SCREEN	996.67	996.67	1159.17	1159.17	3921.67	3921.67
2	RAW MATERIAL NOT USED	38546.05	38546.05	44899.80	44899.80	152913.55	152913.55
3	BOILER FUEL NOT USED	7171.875	7171.875	8500.00	8500.00	31078.13	31078.13
4	ENERGY SAVINGS	5118.75	5687.50	5962.50	6625.00	20306.25	22562.50
5	CHEMICALS NOT USED	399.28	399.28	464.38	464.38	1571.08	1571.08
NET LOSS		2655.22	2657.09	2671.87	2671.72	2955.00	2920.40
MARKET VALUE OF PAPER		9807.21	9249.08	11406.21	10757.08	38589.21	36393.08
TOTAL LOSS		12462.43	11906.17	14078.08	13428.80	41544.21	39313.48

Table 4: (b) Quantitative and Monetary values of elements wasted and saved due to outages of different duration.

HARISAR PAPERS LTD.		PEAK LOAD DURATION					
LOSSES		3 HOURS		3.5 HOURS		12 HOURS	
		2008	2009	2008	2009	2008	2009
1	PRODUCTION LOSS @ 1300 Kg/hr	3986.67	3986.67	4636.67	4636.67	15686.67	15686.67
2	BOILER FUEL WASTAGE @ 1062.5 Kg/hr (Rice Husk),Kg	389.78	389.78	389.78	389.78	389.78	389.78
3	SALARIES PAID TO IDLE STAFF @ Rs 587.43/hr (2008) & Rs 589/hr (2009)	1802.46	1806.88	2096.34	2101.48	7092.30	7092.30
4	DIESEL CONSUMPTION, LITRES	4.04	4.04	4.04	4.04	4.04	4.04
SAVINGS		3 HOURS		3.5 HOURS		12 HOURS	
		2008	2009	2008	2009	2008	2009
1	NO WEAR AND TEAR OF FELT, WIRE, SCREEN @ Rs 0.25/Kg of finished paper	996.67	996.67	1159.17	1159.17	3921.67	3921.67
2	RAW MATERIAL NOT USED @1495 Kg/hr	4534.83	4534.83	5282.33	5282.33	17989.83	17989.83
3	BOILER FUEL NOT USED @ 1062.5 Kg/hr (Rice Husk)	2868.75	2868.75	3400.00	3400.00	12431.25	12431.25
4	ENERGY SAVINGS @ 375 kWh per hour	1137.50	1137.50	1325.00	1325.00	4512.50	4512.50
5	CHEMICALS NOT USED @ Rs 0.10/Kg of paper	399.28	399.28	464.38	464.38	1571.08	1571.08

Table 5: (a) Shows the elements of costs and savings and total loss is calculated for different outage duration.

H.B PAPERS PVT. LTD. (PEAK LOAD)							
LOSSES		3 HOURS		3.5 HOURS		12 HOURS	
		2008	2009	2008	2009	2008	2009
1	PRODUCTION LOSS	42320.05	42933.38	49220.05	49933.38	166520.05	168933.38
2	BOILER FUEL WASTAGE	973.96	973.96	973.96	973.96	973.96	973.96
3	SALARIES PAID TO IDLE STAFF	1046.96	1050.64	1217.66	1221.94	4119.56	4134.04
4	DIESEL CONSUMPTION IN GENERATOR	125.24	133.32	125.24	133.32	125.24	133.32
SAVINGS		3 HOURS		3.5 HOURS		12 HOURS	
		2008	2009	2008	2009	2008	2009
1	NO WEAR AND TEAR OF FELT, WIRE, SCREEN	613.33	613.33	713.33	713.33	2413.33	2413.33
2	RAW MATERIAL NOT USED	29650.8	29650.8	34538.33	34538.33	117951.69	117625.8
3	BOILER FUEL NOT USED	7171.875	7171.875	8500	8500	31078.125	31078.125
4	ENERGY SAVINGS	4930.38	5478.2	5743.08	6381.2	19558.98	21732.2
5	CHEMICALS NOT USED	307.28	307.28	357.38	357.38	1209.08	1209.08
NET LOSS		1792.545	1869.815	1684.79	1772.36	-472.4	116.2
MARKET VALUE OF PAPER		5213.335	4600.005	6063.335	5350.005	20513.335	18100.005
TOTAL LOSS		7005.88	6469.82	7748.125	7122.365	20040.94	18216.21

Table 5: (b) Quantitative and Monetary values of elements wasted and saved due to outages of different duration.

H.B PAPERS PVT. LTD.		PEAK LOAD DURATION					
LOSSES		3 HOURS		3.5 HOURS		12 HOURS	
		2008	2009	2008	2009	2008	2009
1	PRODUCTION LOSS @ 1000 Kg/hr	3066.67	3066.67	3566.67	3566.67	12066.67	12066.67
2	BOILER FUEL WASTAGE @ 1062.5 Kg/hr (Rice Husk)	389.58	389.58	389.58	389.58	389.58	389.58
3	SALARIES PAID TO IDLE STAFF @ Rs341.53 /hr (2008) & Rs 342.43/hr (2009)	1046.96	1050.64	1217.66	1217.66	4119.56	4134.04
4	DIESEL CONSUMPTION, LITRES	4.04	4.04	4.04	4.04	4.04	4.04
SAVINGS		3 HOURS		3.5 HOURS		12 HOURS	
		2008	2009	2008	2009	2008	2009
1	NO WEAR AND TEAR OF FELT, WIRE, SCREEN @ Rs 0.20/Kg of finished paper	613.33	613.33	713.33	713.33	2413.33	2413.33
2	RAW MATERIAL NOT USED @ 1150 Kg/hr	3488.33	3488.33	4063.33	4063.33	13838.33	13838.33
3	BOILER FUEL NOT USED @ 1062.5 Kg/hr (Rice Husk)	2868.75	2868.75	3400.00	3400.00	12431.25	12431.25
4	ENERGY SAVINGS @ 361 kWh per hour	1095.64	1095.64	1276.24	1276.24	4346.44	4346.44
5	CHEMICALS NOT USED @ Rs 0.10/Kg of paper	307.28	307.28	357.38	357.38	1209.08	1209.08

Table 6: (a) Shows the elements of costs and savings and total loss is calculated for different outage duration.

CHAMPION PAPER MILL (PEAK LOAD)							
LOSSES		3 HOURS		3.5 HOURS		12 HOURS	
		2008	2009	2008	2009	2008	2009
1	PRODUCTION LOSS	36238.80	36763.20	42147.30	42757.20	142591.80	144655.20
2	BOILER FUEL WASTAGE	435.38	435.38	435.38	435.38	435.38	435.38
3	SALARIES PAID TO IDLE STAFF	837.20	839.04	955.50	957.60	3294.20	3301.44
4	DIESEL CONSUMPTION IN GENERATOR	81.53	86.79	81.53	86.79	81.53	86.79
SAVINGS		3 HOURS		3.5 HOURS		12 HOURS	
		2008	2009	2008	2009	2008	2009
1	NO WEAR AND TEAR OF FELT, WIRE, SCREEN	414.00	414.00	481.50	481.50	1629.00	1629.00
2	RAW MATERIAL NOT USED	26685.75	26685.75	31084.50	31084.50	105863.25	105863.25
3	BOILER FUEL NOT USED	4905.14	4905.14	5775.85	5775.85	20578.32	20578.32
4	ENERGY SAVINGS	4750.20	5278.00	5533.20	6148.00	18844.20	20938.00
5	CHEMICALS NOT USED	276.00	276.00	321.00	321.00	1086.00	1086.00
NET LOSS		562.28	565.52	424.12	426.12	-1597.40	-1615.30
MARKET VALUE OF PAPER		6541.20	5133.60	7607.70	6997.80	25738.20	23674.80
TOTAL LOSS		7103.48	5699.12	8031.82	7423.92	24140.80	22059.50

Table 6 : (b) Quantitative and Monetary values of elements wasted and saved due to outages of different duration.

CHAMPION PAPER MILL		PEAK LOAD DURATION					
LOSSES		3 HOURS		3.5 HOURS		12 HOURS	
		2008	2009	2008	2009	2008	2009
1	PRODUCTION LOSS @ 900 Kg/hr	2760.00	2760.00	3210.00	3210.00	10860.00	10860.00
2	BOILER FUEL WASTAGE @ 241.87 Kg/hr (Pet Coke)	60.47	60.47	60.47	60.47	60.47	60.47
3	SALARIES PAID TO IDLE STAFF @ Rs 273.22/hr (2008) & Rs 273.94/hr (2009)	837.20	839.04	955.50	957.60	3294.20	3301.44
4	DIESEL CONSUMPTION, LITRES	2.63	2.63	2.63	2.63	2.63	2.63
SAVINGS		3 HOURS		3.5 HOURS		12 HOURS	
		2008	2009	2008	2009	2008	2009
1	NO WEAR AND TEAR OF FELT, WIRE, SCREEN @ Rs 0.15/Kg of finished paper	414.00	414.00	481.50	481.50	1629.00	1629.00
2	RAW MATERIAL NOT USED @1035 Kg/hr	3139.50	3139.50	3657.00	3657.00	12454.50	12454.50
3	BOILER FUEL NOT USED @ 241.87 Kg/hr (Pet Coke)	681.27	681.27	802.20	802.20	2858.10	2858.10
4	ENERGY SAVINGS @ 348 kWh per hour	1055.60	1055.60	1229.60	1229.60	4187.60	4187.60
5	CHEMICALS NOT USED @ Rs 0.10/Kg of paper	276.00	276.00	321.00	321.00	1086.00	1086.00

Table 7: Annual loss calculated for outage duration of different length for three paper mills.

ANNUAL COST SHEET	HARISAR (COST PER OUTAGE)		ANNUAL OUTAGES		ANNUAL COST	
WEEKLY OFF DAYS	2008	2009	2008	2009	2008	2009
16 HOURS	54469.39	51494.49	-	5		257472.45
24 HOURS	80520.31	75856.06	49	75	3945495.2	5689204.5
33 HOURS	109401.8	103263.6	-	1		103263.6
36 HOURS	119095.7	112399.5	8	-	952765.6	
TOTAL			57	81	4898260.8	6049940.6
PEAK LOAD	2008	2009	2008	2009	2008	2009
3 HOURS	12462.43	11906.17	258	238	3215306.94	2833668.46
3.5 HOURS	14078.08	13428.8	51	-	717982.08	
12 HOURS	41544.21	39313.48	-	46		1808420.1
TOTAL			309	284	3933289	4642088.6

ANNUAL COST SHEET	H.B (COST PER OUTAGE)		ANNUAL OUTAGES		ANNUAL COST	
WEEKLY OFF DAYS	2008	2009	2008	2009	2008	2009
16 HOURS	26305.04	23436.81	-	5		117184.05
24 HOURS	38181.44	33878.31	49	75	1870890.6	2540873.3
33 HOURS	51542.34	45624.31	-	1		45624.31
36 HOURS	55996.04	49539.81	8	-	447968.32	
TOTAL			57	81	2318858.9	2703681.6
PEAK LOAD	2008	2009	2008	2009	2008	2009
3 HOURS	7005.88	6469.82	258	238	1807517.04	1539817.16
3.5 HOURS	7748.125	7122.365	51	-	395154.38	
12 HOURS	20040.94	18216.21	-	46		837945.66
TOTAL			309	284	2202671.42	2377762.82
ANNUAL COST SHEET	CHAMPION (COST PER OUTAGE)		ANNUAL OUTAGES		ANNUAL COST	
WEEKLY OFF DAYS	2008	2009	2008	2009	2008	2009
16 HOURS	31712.5	28937.6	-	5		144688
24 HOURS	46856.8	42694.7	49	75	2295983.2	3202102.5
33 HOURS	63893.3	58171.4	-	1		58171.4
36 HOURS	69573.4	63329.5	8	-	556587.2	
TOTAL			57	81	2852570.4	3404961.9
PEAK LOAD	2008	2009	2008	2009	2008	2009
3 HOURS	7103.48	5699.12	258	238	1832697.8	1356390.6
3.5 HOURS	8031.82	7423.92	51	-	409622.82	
12 HOURS	24140.8	22059.5	-	46		1014737
TOTAL			309	284	2242320.7	2371127.6

Table 8(*a*) : Outage cost per specific outage duration and customer damage function in terms of Rs/kWh not supplied, Rs/kWh load disconnected and Outage cost/annual kWh consumption.

HARISAR PAPERS LTD.-CDF						CONNECTED LOAD: 642.5 kW											
Cost Sheet	Actual Time Loss (in Mins)	Harisar (Cost per Outage)		kWh PSEB	kWh Company	CDF (Rs/kWh) Company		CDF (Rs/kWh) PSEB		Ratio of cost to current rate of cost per kilowatt (1kWh =Rs5 in 2008 and Rs5 in 2009)		Ratio of cost to current rate of cost per kilowatt (1kWh=Rs 4.5 in 2008 and Rs5 in 2009) PSEB		Outage cost/annual consumption		Outage cost per kW load disconnected	
WEEKLY OFF DAYS		2008	2009			2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
16 HOURS	962	54469.39	51494.49	6000	6012.5		8.56		8.58		1.71		1.72	0.024	0.026		80.15
24 HOURS	1442	80520.31	75856.06	9000	9012.5	8.93	8.42	8.95	8.43	1.98	1.68	1.99	1.69	0.036	0.039	125.32	118.06
33 HOURS	1982	109401.8	103263.6	12375	12387.5		8.34		8.34		1.67		1.67	0.049	0.053		160.72
36 HOURS	2162	119095.7	112399.5	13500	13512.5	8.81		8.82		1.96		1.76		0.053	0.058	185.36	
AVERAGE						8.87	8.44	8.88	8.45	1.97	1.69	1.88	1.69	0.041	0.044	155.34	119.64
PEAK LOAD		2008	2009			2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
3 HOURS	182	12462.43	11906.17	1125	1137.5	10.95	10.47	11.08	10.58	2.33	2.09	2.22	2.12	0.006	0.006	19.40	18.53
3.5 HOURS	212	14078.08	13428.8	1312.5	1325	10.62		10.73		2.36		2.38		0.006	0.007	21.91	
12 HOURS	722	41544.21	39313.48	4500	4512.5		8.71		8.74		1.74		1.75	0.019	0.020		61.19
AVERAGE						10.78	9.59	10.90	9.66	2.34	1.92	2.30	1.93	0.010	0.011	20.65	39.86

Table 8(*b*) : Outage cost per specific outage duration and customer damage function in terms of Rs/kWh not supplied, Rs/kWh load disconnected and Outage cost/annual kWh consumption.

H.B PAPERS PVT. LTD. - CDF						CONNECTED LOAD: 652 kW											
Cost Sheet	Actual Time Loss (in Mins)	Harisar (Cost per Outage)		kWh PSEB	kWh Company	CDF (Rs/kWh) Company		CDF (Rs/kWh) PSEB		Ratio of cost to current rate of cost per kilowatt (1kWh =Rs5 in 2008 and Rs5 in 2009)		Ratio of cost to current rate of cost per kilowatt (1kWh=Rs 4.5 in 2008 and Rs5 in 2009) PSEB		Outage cost/annual consumption		Outage cost per kW load disconnected	
WEEKLY OFF DAYS		2008	2009			2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
16 HOURS	962	26305.04	23436.81	5779.2	5791.24		4.05		4.06		0.81		0.81	0.0122	0.0125		35.95
24 HOURS	1442	38181.44	33878.31	8668.8	8680.84	4.40	3.90	4.40	3.91	0.98	0.78	0.98	0.78	0.0177	0.0180	58.56	51.96
33 HOURS	1982	51542.34	45624.31	11919.6	11931.64		3.82		3.83		0.76		0.77	0.0238	0.0243		69.98
36 HOURS	2162	55996.04	49539.81	13003.32	13015.24	4.30		4.31		0.96		0.96		0.0259	0.0264	85.88	
AVERAGE						4.35	3.92	4.35	3.93	0.97	0.78	0.97	0.79	0.0199	0.0203	72.22	52.63
PEAK LOAD		2008	2009			2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
3 HOURS	182	7005.88	6469.82	1083.6	1095.64	6.39	5.91	6.465	5.97	1.42	1.18	1.44	1.19	0.003	0.003	10.74	9.92
3.5 HOURS	212	7748.125	7122.365	1264.2	1276.24	6.07		6.13		1.35		1.36		0.004	0.004	11.88	
12 HOURS	722	20040.94	18216.21	4334.4	4346.44		4.19		4.20		0.84		0.84	0.009	0.010		27.94
AVERAGE						6.23	5.05	6.30	5.08	1.38	1.01	1.40	1.02	0.005	0.006	11.31	18.93

Table 8(*c*) : Outage cost per specific outage duration and customer damage function in terms of Rs/kWh not supplied, Rs/kWh load disconnected and Outage cost/annual kWh consumption

CHAMPION PAPER MILL -CDF						CONNECTED LOAD: 610 kW											
Cost Sheet	Actual Time Loss (in Mins)	Harrisar (Cost per Outage)		kWh PSEB	kWh Company	CDF (Rs/kWh) Company		CDF (Rs/kWh) PSEB		Ratio of cost to current rate of cost per kilowatt (1kWh =Rs5 in 2008 and Rs5 in 2009)		Ratio of cost to current rate of cost per kilowatt (1kWh=Rs 4.5 in 2008 and Rs5 in 2009) PSEB		Outage cost/annual consumption		Outage cost per kW load disconnected	
WEEKLY OFF DAYS		2008	2009			2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
16 HOURS	962	31712.5	28937.6	5568	5579.6		5.19		5.20		1.04		1.04	0.015	0.016		47.44
24 HOURS	1442	46856.8	42694.7	8352	8363.6	5.60	5.10	5.61	5.11	1.24	1.02	1.25	1.02	0.022	0.023	76.81	69.99
33 HOURS	1982	63893.3	58171.4	11484	11495.6		5.06		5.07		1.01		1.01	0.030	0.032		95.36
36 HOURS	2162	69573.4	63329.5	12528	12539.2	5.55		5.55		1.23		1.23		0.033	0.035	114.05	
AVERAGE						5.57	5.12	5.58	5.13	1.24	1.02	1.24	1.03	0.025	0.026	95.43	70.93
PEAK LOAD		2008	2009			2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
3 HOURS	182	7103.48	5699.12	1044	1055.6	6.73	5.40	6.80	5.46	1.50	1.08	1.51	1.09	0.0034	0.0031	11.65	9.34
3.5 HOURS	212	8031.82	7423.92	1218	1229.6	6.53		6.59		1.45		1.46		0.0038	0.0041	13.17	
12 HOURS	722	24140.8	22059.5	4176	4187.6		5.27		5.28		1.05		1.06	0.0115	0.0120		36.16
AVERAGE						6.63	5.33	6.69	5.37	1.47	1.07	1.49	1.07	0.0062	0.0064	12.41	22.75

Table 9(*a*) : Annual loss for different outage length and customer damage function in terms of annual outage cost/annual kWh consumption and annual outage cost/annual kWh not supplied.

Annual Cost sheet	Harrisar (Cost per Outage)		Annual outages		Annual Cost		HARISAR PAPERS LTD.	Actual Time Loss (in Mins)	Annual minutes		kWh	Annual outage cost/annual kWh consumption		Annual outage cost/annual kWh not supplied	
WEEKLY OFF DAYS	2008	2009	2008	2009	2008	2009			2008	2009		2008	2009	2008	2009
16 HOURS	54469.39	51494.49	-	5		257472.45		962		4810	6012.5		0.132		0.192
24 HOURS	80520.31	75856.06	49	75	3945495.2	5689204.5		1442	70658	108150	9012.5	1.761	2.925	3.743	4.245
33 HOURS	109401.8	103263.6	-	1		103263.6		1982		1982	12387.5		0.053		0.077
36 HOURS	119095.7	112399.5	8	-	952765.6			2162	17296		13512.5	0.425		0.904	
TOTAL			57	81	4898260.8	6049940.6			87954	114942		1.093	1.037	2.323	1.505
PEAK LOAD	2008	2009	2008	2009	2008	2009			2008	2009		2008	2009	2008	2009
3 HOURS	12462.43	11906.17	258	238	3215306.94	2833668.46		182	46956	43316	1137.5	1.435	1.457	3.05	2.11
3.5 HOURS	14078.08	13428.8	51	-	717982.08			212	10812		1325	0.321		0.681	
12 HOURS	41544.21	39313.48	-	46		1808420.1		722		33212	4512.5		0.930		1.349

Table 9(*b*) : Annual loss for different outage length and customer damage function in terms of annual outage cost/annual kWh consumption and annual outage cost/annual kWh not supplied.

Annual Cost sheet	Harrisar (Cost per Outage)		Annual outages		Annual Cost		H.B. PAPERS PVT. LTD.	Actual Time Loss (in Mins)	Annual minutes		kWh	Annual outage cost/annual kWh consumption		Annual outage cost/annual kWh not supplied	
WEEKLY OFF DAYS	2008	2009	2008	2009	2008	2009			2008	2009		2008	2009	2008	2009
16 HOURS	26305.04	23436.81	-	5		117184.05		962		4810	5791.24		0.062		0.091
24 HOURS	38181.44	33878.31	49	75	1870890.6	2540873.3		1442	70658	108150	8680.84	0.865	1.353	1.854	1.978
33 HOURS	51542.34	45624.31	-	1		45624.31		1982		1982	11931.64		0.024		0.036
36 HOURS	55996.04	49539.81	8	-	447968.32			2162	17296		13015.24	0.207		0.444	
TOTAL			57	81	2318858.9	2703681.6			87954	114942		0.536	0.480	1.149	0.702
PEAK LOAD	2008	2009	2008	2009	2008	2009			2008	2009		2008	2009	2008	2009
3 HOURS	7005.88	6469.82	258	238	1807517.04	1539817.16		182	46956	43316	1095.64	0.836	0.82	1.79	1.198
3.5 HOURS	7748.125	7122.365	51	-	395154.38			212	10812		1276.24	0.183		0.392	
12 HOURS	20040.94	18216.21	-	46		837945.66		722		33212	4346.44		0.446		0.652

Table 9(*c*) : Annual loss for different outage length and customer damage function in terms of annual outage cost/annual kWh consumption and annual outage cost/annual kWh not supplied.

Annual Cost sheet	Harrisar (Cost per Outage)		Annual outages		Annual Cost		CHAMPION PAPER MILL	Actual Time Loss (in Mins)	Annual minutes		kWh	Annual outage cost/annual kWh consumption		Annual outage cost/annual kWh not supplied	
WEEKLY OFF DAYS	2008	2009	2008	2009	2008	2009			2008	2009		2008	2009	2008	2009
16 HOURS	31712.5	28937.6	-	5		144688		962		4810	5579.6		0.079		0.119
24 HOURS	46856.8	42694.7	49	75	2295983.2	3202102.5		1442	70658	108150	8363.6	1.091	1.749	2.411	2.629
33 HOURS	63893.3	58171.4	-	1		58171.4		1982		1982	11495.6		0.032		0.048
36 HOURS	69573.4	63329.5	8	-	556587.2			2162	17296		12539.6	0.264		0.584	
TOTAL			57	81	2852570.4	3404961.9			87954	114942		0.678	0.620	1.498	0.932
PEAK LOAD	2008	2009	2008	2009	2008	2009			2008	2009		2008	2009	2008	2009
3 HOURS	7103.48	5699.12	258	238	1832697.8	1356390.6		182	46956	43316	1055.6	0.871	0.741	1.924	1.114
3.5 HOURS	8031.82	7423.92	51	-	409622.82			212	10812		1229.6	0.195		0.430	
12 HOURS	24140.8	22059.5	-	46		1014737		722		33212	4187.6		0.554		0.833
TOTAL			309	284	2242320.7	2371127.6			57768	76528		0.533	0.648	1.177	0.974

IV. CONCLUSION

A survey on three paper mills has been performed and the results of the survey in form of customer outage costs and customer damage functions have been derived. The primary purpose of conducting this survey was to establish monetary losses associated with various levels of unreliability. CDF portrays the costs associated with outages as a function of outage duration. This is the first ever study on Paper mills in Ludhiana using customer survey approach.

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