Impact of Long Duration Planned Outages on Paper Mills: A Comparative Study 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 was calculated for three paper mills which portray the costs associated with outages as a function of outage duration.**

Index Terms—**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. 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, reduced customer satisfaction and 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. METHODOLOGY

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 [1]. 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]. Researchers divided the cost incurred by consumers due to electrical interruptions into two categories direct cost and 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 [4], [5]. 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 was collected while a conversation with the customer. That data was then extrapolated and interpolated to get the useful observations.

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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: Loss in production, Cost of Idle Manpower, Cost of running backup generator, Cost of boiler fuel wastage and Cost of Market value.
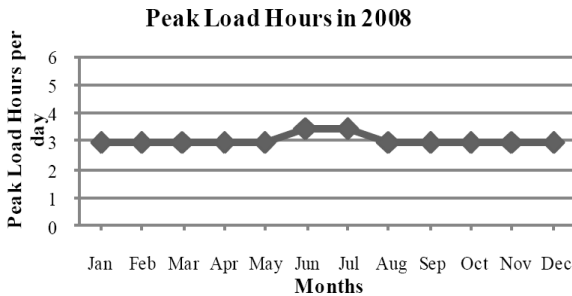
III. RESULTS AND DISCUSSIONS

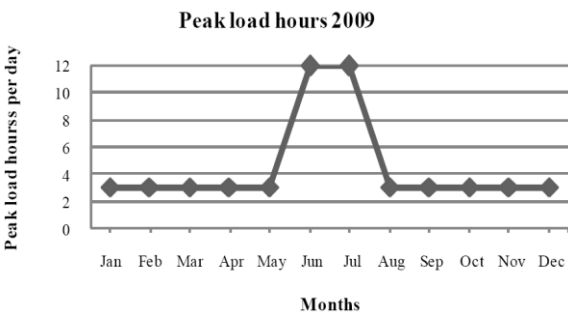Fig.1. Shows the peak load hours per day in each month occurred in 2008 and 2009

Fig. 2. Shows the peak load hours per day in each month occurred in 2009
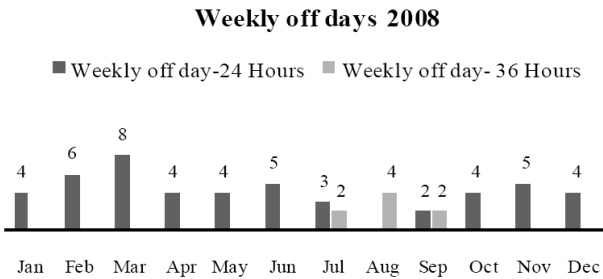

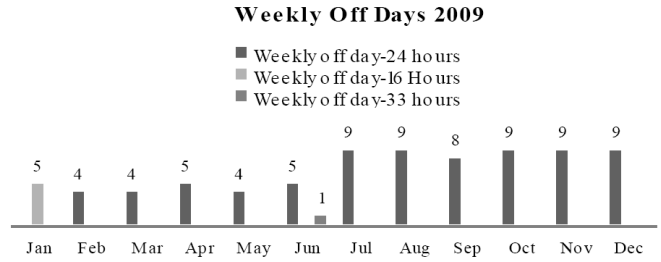Fig. 3. Represents the number of weekly off days per month in 2008

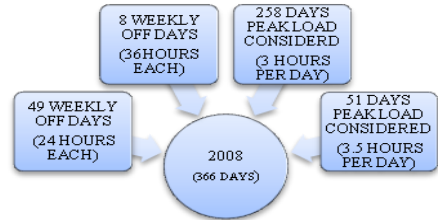Fig. 4. Represents the number of weekly off days per month in 2009

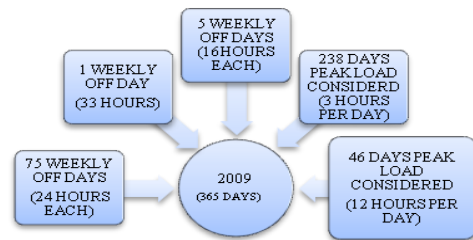Fig. 5. Represents the summarized data regarding off days and peak load

Fig. 6. Represents the summarized data regarding off days and peak load

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. 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.

TABLE I: 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	DIESAL 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 II: 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 DIESAL 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 III: 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 DIESAL 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 IV: 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 DIESAL 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 V: 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	**DIESAL 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 VI: 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	**DIESAL 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 VII: 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 VIII: CUSTOMER DAMAGE FUNCTION ASSOCIATED WITH WEEKLY OFF DAYS.

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		Outage cost per kW load disconnected		Ratio of cost to current rate of cost per kilowatt (1KW-h=Rs 4.5 in 2008 and Rs 5 in 2009) COMPANY		Ratio of cost to current rate of cost per kilowatt (1KW-h=Rs 4.5 in 2008 and Rs 5 in 2009) PSEB	
WEEKLY OFF DAYS		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		80.15		1.71		1.72
24 HOURS	1442	80520.31	75856.06	9000	9012.5	8.93	8.42	8.95	8.43	125.32	118.06	1.98	1.68	1.99	1.69
33 HOURS	1982	109401.8	103263.6	12375	12387.5		8.34		8.34		160.72		1.67		1.67
36 HOURS	2162	119095.7	112399.5	13500	13512.5	8.81		8.82		185.36		1.96		1.76	
AVERAGE						8.87	8.44	8.88	8.45	155.34	119.64	1.97	1.69	1.88	1.69
H.B PAPERS PVT. LTD. – CDF							**CONNECTED LOAD: 652 kW**								
COST SHEET	ACTUAL TIME LOSS (IN MINS)	H.B (COST PER OUTAGE)		kWh PSEB	kWh Company	CDF (Rs/kWh) Company		CDF (Rs/kWh) PSEB		Outage cost per kW load disconnected		Ratio of cost to current rate of cost per kilowatt (1KW-h=Rs 4.5 in 2008 and Rs 5 in 2009) COMPANY		Ratio of cost to current rate of cost per kilowatt (1KW-h=Rs 4.5 in 2008 and Rs 5 in 2009) PSEB	
WEEKLY OFF DAYS		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		35.95		0.81		0.81
24 HOURS	1442	38181.44	33878.31	8668.8	8680.84	4.40	3.90	4.40	3.91	58.56	51.96	0.98	0.78	0.98	0.78
33 HOURS	1982	51542.34	45624.31	11919.6	11931.64		3.82		3.83		69.98		0.76		0.77
36 HOURS	2162	55996.04	49539.81	13003.32	13015.24	4.30		4.31		85.88		0.96		0.96	
AVERAGE						4.35	3.92	4.35	3.93	72.22	52.63	0.97	0.78	0.97	0.79
CHAMPION PAPER MILL –CDF							**CONNECTED LOAD: 605 kW**								
COST SHEET	ACTUAL TIME LOSS (IN MINS)	CHAMPION (COST PER OUTAGE)		kWh PSEB	kWh Company	CDF (Rs/kWh) Company		CDF (Rs/kWh) PSEB		Outage cost per kW load disconnected		Ratio of cost to current rate of cost per kilowatt (1KW-h=Rs 4.5 in 2008 and Rs 5 in 2009) COMPANY		Ratio of cost to current rate of cost per kilowatt (1KW-h=Rs 4.5 in 2008 and Rs 5 in 2009) PSEB	
WEEKLY OFF DAYS		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		47.83		1.04		1.04
24 HOURS	1442	46856.8	42694.7	8352	8363.6	5.60	5.10	5.61	5.11	77.45	70.57	1.24	1.02	1.25	1.02
33 HOURS	1982	63893.3	58171.4	11484	11495.6		5.06		5.07		96.15		1.01		1.01
36 HOURS	2162	69573.4	63329.5	12528	12539.2	5.55		5.55		115.00		1.23		1.23	
AVERAGE						5.57	5.12	5.58	5.13	96.22	71.52	1.24	1.02	1.24	1.03

TABLE IX: CUSTOMER DAMAGE FUNCTION ASSOCIATED WITH PEAK LOAD.

HARISAR PAPER MILL-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		Outage cost per kW load disconnected		Ratio of cost to current rate of cost per kilowatt (1KW-h=Rs 4.5 in 2008 and Rs 5 in 2009) COMPANY		Ratio of cost to current rate of cost per kilowatt (1KW-h=Rs 4.5 in 2008 and Rs 5 in 2009) PSEB	
PEAK LOAD		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	19.40	18.53	2.33	2.09	2.22	2.12
3.5 HOURS	212	14078.08	13428.8	1312.5	1325	10.62		10.73		21.91		2.36		2.38	
12 HOURS	722	41544.21	39313.48	4500	4512.5		8.71		8.74		61.19		1.74		1.75
AVERAGE						10.78	9.59	10.90	9.66	20.65	39.86	2.34	1.92	2.30	1.93

H.B PAPERS PVT. LTD.-CDF — **CONNECTED LOAD: 652kW**

COST SHEET	ACTUAL TIME LOSS (IN MINS)	H.B (COST PER OUTAGE)		kWh PSEB	kWh Company	CDF (Rs/kWh) Company		CDF (Rs/kWh) PSEB		Outage cost per kW load disconnected		Ratio of cost to current rate of cost per kilowatt (1KW-h=Rs 4.5 in 2008 and Rs 5 in 2009) COMPANY		Ratio of cost to current rate of cost per kilowatt (1KW-h=Rs 4.5 in 2008 and Rs 5 in 2009) PSEB	
PEAK LOAD		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	10.74	9.92	1.42	1.18	1.44	1.19
3.5 HOURS	212	7748.125	7122.365	1264.2	1276.24	6.07		6.13		11.88		1.35		1.36	
12 HOURS	722	20040.94	18216.21	4334.4	4346.44		4.19		4.20		27.94		0.84		0.84
AVERAGE						6.23	5.05	6.30	5.08	11.31	18.93	1.38	1.01	1.40	1.02

CHAMPION PAPER MILL-CDF — **CONNECTED LOAD: 605 kW**

ANNUAL COST SHEET	ACTUAL TIME LOSS (IN MINS)	CHAMPION (COST PER OUTAGE)		kWh PSEB	kWh Company	CDF (Rs/kWh) Company		CDF (Rs/kWh) PSEB		Outage cost per kW load disconnected		Ratio of cost to current rate of cost per kilowatt (1KW-h=Rs 4.5 in 2008 and Rs 5 in 2009) COMPANY		Ratio of cost to current rate of cost per kilowatt (1KW-h=Rs 4.5 in 2008 and Rs 5 in 2009) PSEB	
PEAK LOAD		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	11.65	9.34	1.50	1.08	1.51	1.09
3.5 HOURS	212	8031.82	7423.92	1218	1229.6	6.53		6.59		13.17		1.45		1.46	
12 HOURS	722	24140.8	22059.5	4176	4187.6		5.27		5.28		36.16		1.05		1.06
AVERAGE						6.63	5.33	6.69	5.37	12.41	22.75	1.47	1.07	1.49	1.07

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. It has been observed that customer damage function values were maximum for Harisar Paper Mill followed by H.B Papers Pvt. Ltd and Champion Paper Mill This is the first ever study on Paper mills in Ludhiana using customer survey approach.

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