The Impact and Cost of Power Load shedding to Domestic Consumers

By

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Abstract

This paper analyses the impact and cost of the high level of power load shedding to domestic consumers in 2012 by a survey based approach. The paper develops a methodology for quantification of the cost of outages by deriving the utility loss, cost of self-generation and other costs incurred. Overall, the total outage cost to residential consumers in the urban areas of Pakistan is estimated at close to Rs 200 billion. The willingness to pay more for uninterrupted electric supply is also determined. Policy recommendations are made to mitigate the impact of load shedding on domestic consumers.

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1. INTRODUCTION

The widespread and growing phenomenon of power load shedding has emerged as one of the principal supply-side constraints to growth of the economy of the Pakistan. Not only has this led to significant losses of output, employment and exports but also during periods of high outages there have been large-scale protests, particularly in Punjab and K-PK.

Households have faced severe disruptions due to the high and growing incidence of load shedding. These have led to mass protests on streets resulting in disruption of other economic activities. As such, the economic return of reducing outages and of facilitating the process of adjustment to these outages is likely to be high.

This paper provides an approach and methodology for quantifying cost of load shedding to households in Pakistan. It is organized as follows: Section 2 highlights some key trends in the power sector of Pakistan. Section 3 will present a detailed literature review on the methodology used for quantification of costs due to outages. Section 4 describes the methodology used for qualification of costs due to outages and for estimation of willingness to pay. Section 5 presents estimates of the cost of load shedding in the domestic sector of Pakistan. Finally, Section 6 highlights the major policy implications emerging from the research.

2. THE POWER SECTOR

The growth in installed capacity and generation of electricity in Pakistan is presented in Table 1 since 1970-71. The former has been more than doubling every decade up to 2000-01, with annual growth rate over 7%. It is only during the last decade that the rate of expansion in capacity has substantially slowed down to less than 3% per annum. In the initial years of the decade there was significant excess capacity, due to the hump in investment by the IPPs in the mid-to late-90s. But adequate provisions were not made to cater for the future growth in demand.

The growth in electricity generation was rapid in the 70s and 80s. in particular, the commissioning of the Tarbela Dam in the early 80s enabled a quantum jump in supplies at low cost. During the 90s as the growth rate of the economy slowed down, demand for electricity was not so buoyant and the rate of increase annually in power generation declined to 5%. During the last decade, this has fallen further to only 3%.

Table 1
Long-Term Trend in Capacity and Generation in Pakistan of Electricity 1970-71 to 2011-12

	Installed Capacity (MW)	Annual Growth Rate (%)	Electricity Generation (GWH)	Annual Growth Rate (%)	Index of Capacity Utilization (%)
1970-71	1862		7202		81
1980-81	4105	8.2	16062	8.4	82
1990-91	8356	7.4	41042	9.8	102
2000-01	17498	7.7	68117	5.2	81
2011-12	23358	2.7	98664	3.4	88

Source: Handbook of Statistics, SBP, Pakistan Economic Survey, MOF, GOP

An index of capacity utilization† is constructed in Table 1. The rate of capacity utilization exceeded 100% by 1990-91 and the load shedding which occurred in a significant way in the mid-to-late-80s can be attributed to a shortage of capacity. It was during this period that the first study in Pakistan on costs of load shedding was undertaken by Pasha, Ghaus and Malik [1989]. As opposed to this, the upsurge in load shedding once again since 2007-08 can be attributed primarily to a lack of full capacity utilization arising from lack of adequate maintenance of older plants and liquidity problems due to the ballooning of circular debt and to the slow expansion in capacity.

The growth in electricity consumption by type of consumer during the last decade is presented in Table 2. The analysis is broken up into two sub-periods, the years prior to commencement of significant load shedding in 2007-08 and the years thereafter. In the latter period, the overall level of power consumption has declined with marginal growth only in the case of industrial consumers.

Table 2
Growth in Electricity Consumption from 2000-01 to 2011-12
(GWH)

	Domestic	Industrial	Commercial	Agricultural	Others*	Total
2000-01	22765	14349	1774	4924	3773	48585
2007-08	33704	20129	5572	8472	4923	73400
2011-12	33138	21334	5526	8290	4760	73084
Growth Rate (%)						
2000-01 to 2007-08	5.8	5.4	10.5	8.1	6.7	6.1
2007-08 to 2010-11	2.1	0.8	0.5	1.9	2.2	1.6
2001-01 to 2011-12	-0.4	1.5	-0.2	-0.5	-0.7	-0.2

* mostly government, street lights and traction
Source: PES

† 300 days operation with 16 hours daily.

The surplus/deficit between demand and supply during system peak hours for National Transmission & Despatch Company (NTDC) and Karachi Electric Supply Corporation (KESC) combined is given Table 3. The supply gap was 1912 MW in 2007 which has risen to 6518 MW, equivalent to 29 % of demand. It is important to note that in 2011-12 National Electric Power Regulatory Authority (NEPRA) reports the generation capability as less than 70% of the installed capacity.

Table 3
Surplus/Deficit in Demand and Supply during System* Peak Hours

	Generation Capacity	Demand	Supply-Gap	%
2007	15575	17487	-1912	11
2008	14707	19281	-4574	24
2009	16050	20304	-4254	26
2012	16104	22622	-6518	29

* NTDC and KESC combined
Source: NEPRA, State of Industry Report

According to NEPRA, the highest incidence of outages regionally is in the area served by Multan Electric Power Company, Peshawar Electric Supply Company and Lahore Electric Supply Company. The least outages are in Islamabad Electric Supply Company. Most areas of Punjab and Khyper-Pakhtunkhwa are more vulnerable to load shedding.

Incidence of Loadshedding

The costs of load shedding, to a large extent, depend on the frequency and duration of outages. The incidence of load shedding is given in Table 4.

Table 4
Incidence of Load shedding

	No of Times there is a Load shedding in a Day	Annual Hours of Outages
By Province		
Punjab	6	1683
Sindh	3	1123
KPK	4	1216
Baluchistan	4	1069
By Income Group		
Upto 15000	5	1498
15001-35000	4	1394
35001-70000	5	1430
70001 +	5	1702
Total	**5**	**1453**

Overall, on an average outages occurred 5 times a day in Pakistan in 2012, highest being in Punjab, 6 times. Households, on an average did not have electricity supply from power distribution companies for 1453 hours in 2012. The highest load shedding has occurred in Punjab at 1683, followed by K-PK, 1216. Clearly, the average incidence is lower in Sindh and Balochistan.

3. LITERATURE REVIEW

Various approaches have been developed in the literature for quantification of the cost incurred by different types of consumers as a result of power outages. These approaches vary greatly in terms of data requirements and level of complexity. This section starts with the simple value added approach and ends with the full-blown survey based and contingent valuation approaches.

The Simple Value Added Approach

A relatively high estimate of the cost of loadshedding is as follows:

V_i = Value added by sector i in absence of Loadshedding

E_i = Electricity consumption in the absence of loadshedding

Then the cost C_i, of loadshedding is give by

$$C_i = \frac{V_i}{E_i} l_i \quad \text{.........(1)}$$

Where l_i is the quantum of electricity not supplied due to outages. Summing across sectors, the total cost of loadshedding is given by

$$C = \sum_{i=1}^{n} \frac{V_i}{E_i} l_i \quad \text{.........(2)}$$

Where n is the number of sectors.

This approach can be applied on the production sectors of the economy, viz, agriculture, industry and commerce, but not to domestic consumption of electricity.

The reasons why this approach leads to a high estimate of the cost of Load shedding are as follows:

(i) It does not distinguish between the average and marginal productivity of the electricity input, that is, there could be some economies of scale in the use of energy.

(ii) It assumes that output lost is proportional to the extent of electricity not supplied and the firms do not make adjustments to recover at least part of the output.

As opposed to the above, an approach that yields a low estimate is one which focuses only the wage cost, on the assumption that the idle factor during outages is labor. As such, in this case

$$C_i = \frac{W_i}{E_i} l_i \quad \text{.........(3)}$$

Where W_i is the wage bill.

The Adjusted Value Added Approach

This approach postulates the marginal cost of unsupplied electricity is different from the average cost as given in (1) above. Accordingly,

$$\frac{\partial V_i}{\partial E_i} = \beta \frac{V_i}{E_i} \qquad \beta > 0 \qquad \text{.. (4)}$$

β is estimated on the basis of the historical relationship between value added and electricity consumption. Generally, it is observed that β <1.

However, the value added approaches suffer from the defect that they do not allow for spoilage costs arising from damage to materials that takes place at the time when the outage occurs, especially if there is no prior notice.

Marginal Cost of Unsupplied Electricity

It has been argued by Bental [1982] that by observing a firms behavior with respect to the acquisition of own generating power, the marginal cost of unsupplied electric energy may be inferred. A competitive risk-neutral firm equates, at the margin, the cost of generating a kwh on its own to the expected gain due to that kwh. This expected gain is also the expected loss from the marginal kwh which is not supplied by the utility. Therefore, the marginal cost of generating its own power may serve as an estimate of the marginal outage cost.

The cost to a firm of generating its own power consists of the two elements. The first part is the yearly capacity cost of the generator. This can be represented as follows:

K(c) = annual capital cost (depreciation + interest cost) of a generator with capacity in kva

In addition,

VC = variable cost per Kwh, consisting mainly of fuel cost

l = hours of outages

The marginal cost, MC of self-generation per Kwh is given by

$$MC = \frac{\partial K(c)}{\partial c} + vc \text{....................................... (5)}$$

On the assumption that the MC is constant, the total cost, TC, of Loadshedding is given by

$$TC = MC.l \qquad \text{... ... . (6)}$$

This approach may not lead to proper estimates in the following cases:

(i) Presence of economies/ diseconomies of scale in the capital cost of generators such that $\frac{\partial K(c)}{\partial c}$ is not constant.

(ii) Imperfections in the capital market whereby firms, especially the smaller ones, are unable to borrow for acquisition of a generator.

(iii) In Pakistan previous surveys of firms, for example by the Institute of Public Policy [2009], indicated that not all units have self-generation. This implies that the marginal cost of outages is lower than the marginal cost of a generator. For such units, this method cannot, therefore be applied.

The Value of Leisure Approch

M. Munasingha [1980] has proposed a novel approach for evaluating the cost of outages to residential consumers, as the value of leisure foregone. According to this approach, the principal outage cost imposed on a household is the loss of leisure during the evening hours when electricity is essential. During the day time there is sufficient slack in the execution of household activities that are interrupted by the outage, such as cooking or cleaning, to permit rescheduling of these activities without causing much inconvenience.

As such, the monetary value of this lost leisure is equal to income earning rate on the basis of consumers' labor–leisure choice. Munashinghe accordingly computes the cost per Kwh of unsupplied electricity as

$$C = \frac{y}{k} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Where y is the hourly income and k the normal level of electricity consumed per hour in the absence of outages. Therefore, the total cost of outages to residential consumer is, C, where

$$C = \frac{y}{k} \,.\, l \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

A principal practical advantage of this method of estimating outage costs for residential consumers is that it relies on the relatively easy-to-obtain data. But for proper application of this method it is essential to have the levels of electricity consumption by households at different income levels.

Other problems with this approach include the following:

(i) It assumes that the income earner in the household has flexible working hours so that he/she can effectively exercise his/her labor-leisure choice. This may be true in the case of self-employed persons. But for wage earners who work fixed hours, the marginal value of leisure is unlikely to be equal to the income rate per hour. As such, some authors have preferred to apply this approach by assuming that the value of leisure is only a fraction of income.

(ii) It ignores the presence of household economic activities like cottage industry or sewing/embroidery work by women, especially in lower income households. This is sometimes the case in Pakistan. Such, activities may not readily be rescheduled in the presence of outages, especially if they are of long durations. As such, in these cases the cost of outages must include the value of lost output.

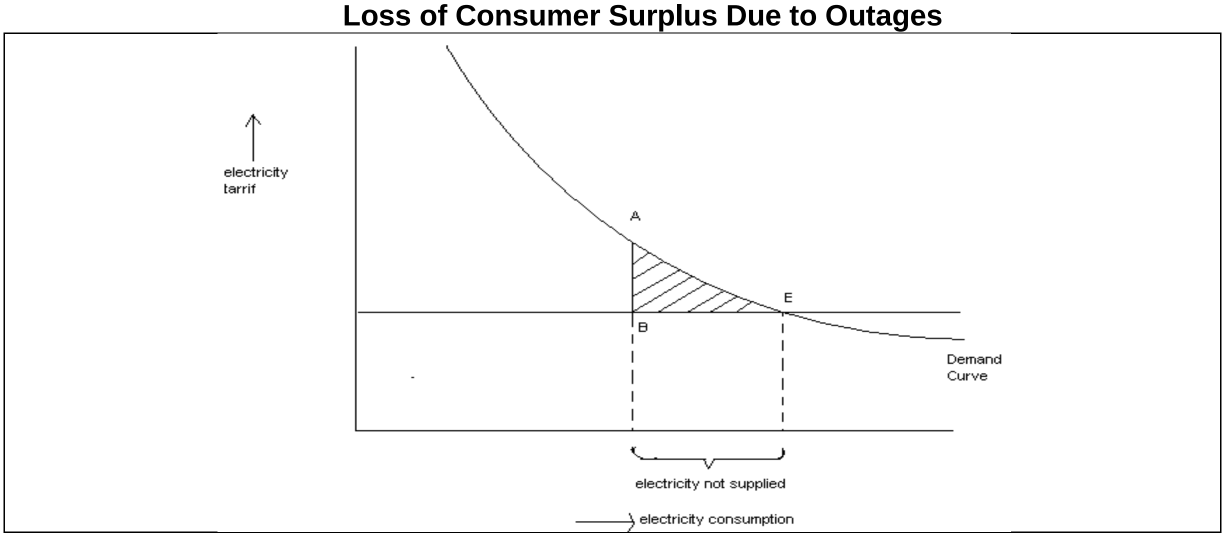
(iii) Outages, especially when accompanied with voltage fluctuations, can damage home-based appliances like TV, refrigerator, air-conditioner, freezer, etc. Cost has to be incurred to repair the damage. These are equivalent to spoilage costs and should be included in the cost of loadshedding.

The Consumer Surplus Approach

This is relatively popular approach and has been applied by Sanghvi [1982]. The demand curve for electricity captures the willingness to pay for the service and the consumer surplus of electricity supply is represented by the area between the demand and supply curves. The loss of consumer surplus due to supply interruptions is represented by the shaded area, **ABE,** in Figure 1 below.

Figure 1

Loss of Consumer Surplus Due to Outages



The prime magnitude required for application of this approach is the price elasticity of demand, which is not possible to measure in the presence of outages. Also, given a non-linear schedule of power tariffs, as is the case with residential consumers in Pakistan, the magnitude of the consumer surplus lost due to outages becomes difficult to quantify. Further, if AB is large then the consumer may be able to reduce the loss by investing in self-generation. This becomes more attractive the larger the amount of electricity not supplied.

The Contingent Valuation (WTP) Approach

This approach involves asking consumers their willingness to pay for more reliable supplies of power. For example, the question could be as follows:
If the incidence of outages is reduced to half its present level, how much more would you be willing to pay on your monthly electricity bill?

An alternative approach is to ask the following question:
If level of outages were to double, what reduction in your monthly electricity bill would you consider to be fair?

The contingent valuation approach is prone to giving biased estimates as it is based on subjective responses. It is likely that in response to the first question the consumer understates his willingness to pay for improved service, while he may overstate the compensation that he would like to receive for deterioration in the reliability of supply.

The Survey Based Approach

The most comprehensive approach to quantify the cost of outages is to undertake a random survey of affected consumers. This enables explicit and direct determination of different components of outage costs including the spoilage cost, idle factor cost and adjustment cots.

However, the survey based approach is more costly than approaches which rely largely on secondary data. Also, the possibility of a bias cannot be ruled out by the respondents who may exaggerate the costs in order to attract greater attention to the problem of load shedding.
We apply each of the above approaches to quantification of outage costs to domestic consumers in light of the data obtained from the survey of 500 households in Pakistan.

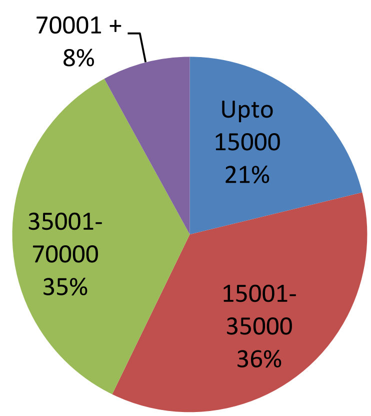
Table 5 gives the sample distribution by city the sample was distributed among cities on the basses of share of city in provincial population. 57 percent of the sample household units are in the province of Punjab while about 22 percent are in Sindh. From the remaining 33 percent, 15 percent are in Khyber-Pakhtunkhwa (K-PK) and 6 percent in Balochistan.

Table 5
Distribution of Sample by Province and by City

Provinces	Cities	Numbers	Percentage
Punjab	Lahore	96	19
	Faisalabad	51	10
	Sialkot	13	3
	Gujranwala	26	5
	Multan	38	8
	Rawalpindi/Islamabad	61	12
	Total	**285**	**57**
Sindh	Karachi	80	16
	Hyderabad	20	4
	Sukkur	10	2
	Total	**110**	**22**
KPK	Peshawar	50	10
	Mardan	13	3
	Abbotabad/Bannu	12	2
	Total	**75**	**15**
Balochistan	Quetta	30	6
	Total	**30**	**6**
Total		**500**	**100**

The distribution of sample households by income group is given in Figure 2. About 21 percent of the households have permanent monthly income, proxied by monthly consumption expenditure, of upto Rs. 15000, 36 percent have income between Rs 15000 to Rs. 35000, 35 percent have income between Rs. 35000 to Rs.70000 while 8 percent have income above 70000 per month. The overall average monthly income of sample households is Rs. 38429.

Figure 2
Distribution of Selected Households by Income Group



Value of Leisure Approach

Munasinghe [1980] argued that the outage cost corresponds to the value of leisure, which he proxies by income.

The estimated outage cost per kwh for domestic consumers based on this approach is derived from the Survey as Rs 91 per kwh in Table 6. The Munasinghe approach yields very high estimates.

Table 6
Outage Cost per kwh
according to the Value of Leisure Approach*

Group (Rs per Month)	Income** per hour	Electricity Consumption per hour***(kwh)	Outage Cost per kwh (Rs)
0-15000	67.5	0.9	75
15001-35000	144.8	1.5	97
35001-70000	295.5	3.3	90
Above 70000	612.6	5.7	107
Total	**218.3**	**2.4**	**91**

*Y = income per hour worked based on 8 hours a day for 22 days a month.
Kwh = normal power consumption per hour (in public supply)
**Proxied by consumption expenditure, which is assumed to correspond to permanent income
***On the assumption that electricity is consumed 16 hours a day. The consumption of electricity in the evenings is assumed to be three times the daily average.

There is another way of examining the validity of assumptions made by Munasinghe. Respondents were asked which activities are disrupted most in the household by load shedding. The frequency of different responses is given in Table 7.

Table 7
Activities most Disturbed by Load shedding

	% of sample units
Cooling/heating	24.4
Studies (home work) of children	18.2
Preparation for work/school	17.4
Regular household work (cooking, cleaning, etc.)	14.6
Shortage of water	13.0
Income generating activities (home based)	8.2
Social Activities	2.2
Entertainment, leisure	2.0
Total	**100.0**

Leisure is reported by only two percent of the sample households as the activity most disturbed by load shedding. Other activities are of greater importance to households, including cooling/heating, studies of children and preparation for work/school reported 24 percent, 18 percent and 17 percent respectively as the principal activity affected by outages. Therefore, the Munasinghe hypothesis that leisure is the activity most disrupted is not borne out by the data obtained from households in Pakistan.

It is our view that the Munasinghe approach has a developed country bias. It cannot be applied in the context of low-to-middle income countries like Pakistan. A significant and new finding is the impact of outages on children, either in terms of the ability to undertake studies (homework) or in preparation to go to school.

Generator Cost Approach

This approach is based on the assumption that the principal form of adjustment to outages by households is the acquisition of a generator and/or a UPS (Uninterrupted Power Supply). As such, the cost of self-generation corresponds to the outage cost.

The question that arises is if a household does not have a generator/UPS then is the outage cost zero? Clearly, this is not the case.

It is likely that there are outage costs, especially in terms of the monetized value of the utility lost due to disturbance to some household activities, but these costs may not be large enough to justify the resort to self-generation.

Table 8 gives the percentage of households by level of consumption expenditure with a generator and/or UPS. Overall, 28 percent of the households have a generator and 30 percent have UPS. Poorer households generally are unable to self-generate electricity. However, majority of the households in the upper most income group have made arrangements for alternative sources of power at the time of load shedding.

Table 8
Sample Households with Generator and/or UPS

	% of Sample Households	
Level of monthly consumption expenditure (Rs)	**With Generator**	**With UPS**
0-15,000	2	4
15,001-35,000	17	26
35,001-70,000	45	47
70,001 and above	75	43
Total	**28**	**30**

Given the high percentage of households which do not have self-generation the issue is one of quantifying the cost of outages in the case of such households.

Willingness to Pay

The willingness to pay approach provides the basis for determining the subjective valuation by households of the cost of outages to them. There is, of course, the likelihood of a ‘free rider’ problem here. A household may understate its willingness to pay on the expectation that other households may reveal a high enough WTP to justify investment in improving the reliability of the power system.

Table 9 indicates the outage cost per hour as implied by the WTP. This can be estimated as follows:

$$SOCKW = \left(\frac{WTP}{100}\right)\frac{AEB}{ENS} \quad \cdots\cdots (1)$$

Where,

SOCKW = subjective valuation by household of the outage cost per kwh

WTP = % higher tariff that the household is willing to pay for improved reliability of power supply (with minimal outages)

AEB = Annual electricity bill paid to the DISCO/KESC

ENS = electricity not supplied in the outages.

Table 9
Subjective Valuation of the Outage Cost per Hour

Monthly Expenditure Group	Willingness to Pay (extra over tariff)	Annual Electricity Bill	Electricity not Supplied	Subjective Valuation by Household of Outage Cost per Hour
(Rs)	(%)	(Rs)	(kwh)	(Rs per kwh)
0-15000	30.3	15330	479	9.70
15001-35000	28.7	28836	732	11.31
35001-70000	28.3	65094	1599	11.52
70001 and above	31.8	130590	4299	9.66
Total	**29.2**	**46734**	**1289**	**10.59**

It is interesting to note that while the subjective valuation of the outage cost per hour is somewhat low at below Rs 11 per kwh, it is higher for households belonging to the 'middle class'.

4. METHODOLOGY FOR QUANTIFICATION OF OUTAGE COST

The methodology for quantification of outage cost to domestic consumers is qualitatively different from that used in the case of industrial and commercial consumers. The basic reason for this is that there is no notion of 'output' in the case of a household‡, which is more of a consuming unit. As such, outages impact on the level of utility/quality of life of a household.

The exposure to outages daily is given by DLOUT where

$D = \sum_{i=1}^{n} n_i d_i$ .... (1)

Where n_i = number of outages of duration d_i , i = 1, …..n.

The normal level of electricity consumption per hour is given

e = $\frac{(Kwh_1 + Kwh_2)}{8760-365D}$ .... (2)

Where, Kwh_1 = electricity purchased from the distribution company during summer months

Kwh_2 = electricity purchased from the distribution company during winter months

The normal consumption of electricity during times when there are no outages depends upon the number of electrical appliances at home. As such,

$e = \beta_o + \sum_{j=1}^{m} \beta_j A_j$ .... (3)

Where, β_j *= electricity consumption by appliance j, where j =1,2,3,……..,m.

$A_j =$ number of appliance j

$\beta_o =$ basic electricity consumption (e.g. for lighting).

Depending upon the nature of use of particular appliances the share of electricity consumed in different activities like heating/cooling, household functions, entertainment/leisure is derived. That is

$\sum_{k=1}^{r} W_k = 1$ .... (4)

Where W_k= share in electricity consumption of activity k, k=1,2,……,r.

If a household has a generator then the sample household has reported if a particular activity can be performed during the outages in the presence of a generator, and

$P_k^1 = 1$ if activity k can be performed during the outage.

$P_k^1 = 0$ if activity k cannot be performed during the outage.

‡ With the exception of households which engage in some economic activity at home.

*The β_j is estimated by OLS regression across the sample households of electricity consumption per hour with ownership of different types of appliances.

Then the extent of substitution, S, by the generator of public supply during outages is given by S_1 where

$$S_1 = \sum_{k=1}^{r} W_k P_k^1 \quad \text{.............. (5)}$$

Similarly, the extent of substitution by a household which has a UPS can be derived

$$S_2 = \sum_{k=1}^{r} W_k P_k^2 \quad \text{.............. (6)}$$

It may, of course, be noted that in the case of household which has neither a generator nor an UPS, S_1=0, S_2=0.

For a household which has a generator the costs of operation have been obtained as

$$G_c = K(i + \delta) + 12f + 4(m + o) - T \quad \text{.......... (7)}$$

Where, K = capital cost, I = annual interest rate, δ = annual rate of depreciation, f = monthly fuel cost, m = quarterly maintenance costs, o = quarterly other costs, T = savings in terms of payment to the utility.

Similarly, the cost of a UPS can be derived as G_u . In this case T = 0 because the UPS stores electricity obtained at the time when there are no outages.

There are also other costs arising from the outages, including spoilage cost, SPC, damage to appliances, DAC and miscellaneous costs, MC.

The last part of the methodology relates to the valuation of costs arising from disturbance of activities which cannot be performed or only partially performed during the outages either because of the absence of self-generation or because of only partial substitution by generator/UPS.

These costs are subjective in nature in terms of a loss of utility and are, therefore, not observed. We use the willingness-to-pay (WTP) as a measure of the subjective costs and apply this magnitude to the part of the electricity consumption which is not substituted by self-generation during outages. As such,

$$MUTL = WTP(B_1 + B_2)(1 - S_1 - S_2) \quad \text{................(8)}$$

Where, WTP = extent of higher tariff that household is willing to pay for better quality of service (with minimal outages)

B1 = electricity bill of the distribution company during summer months

B2 = electricity bill of the distribution company during winter months

The overall outage costs to the household, OTC, is given by

$$OTC = G_c + G_u + SPC + DAC + MC + MUTL \quad \text{.................(9)}$$

In the case of a household with no self-generation capacity

$$OTC = SPC + DAC + MC + MUTL$$

Where, $MUTL = WTP(B_1 + B_2)$

This methodology is new and has not been used yet in other studies.

5. RESULTS

The objective of this section is to present the estimated magnitudes of different types of costs associated with outages. As identified in previous section, these include direct costs which consist of spoilage costs and indirect or adjustments costs which include generator costs and UPS costs.

Total Outage Costs

Table 10 shows that the total outage cost on average to each residential consumer is almost 31,000 Rs per annum. The variation in outage costs is not very large among Provinces, ranging from about Rs 29,200 per consumer in Punjab to Rs 34,100 in K-PK.

Outage costs rise sharply by consumption (income) level of a consumer. For households with monthly consumption expenditure of upto Rs 15000, the outage cost annually is Rs 8800. For the highest expenditure group of households the cost rises to Rs 75200.

Table 10
Total Outage Cost per Residential Consumer

(Rs)

	Monetization of Utility Loss	Cost of Self-Generation		Other Costs	Total Outage Cost
		Generator Cost	UPS Cost		
By Province					
Punjab	7355	11263	3864	6747	29229
Sindh	7626	17562	2054	6075	33317
K-PK	4954	18964	2037	8104	34059
Balochistan	3530	18120	2573	5235	29458
By Income Group(Rs)					
0 – 15000	3828	290	400	4262	8780
15001 – 35000	5655	6380	2734	6749	21518
35001 – 70000	9544	22370	4831	7053	43798
70001 and above	8193	50900	4550	4549	75192
Total	**6824**	**14215**	**3114**	**6712**	**30865**
Share (%)	**22**	**46**	**10**	**22**	**100**

Overall, for the sample as a whole, the largest component of outage costs is self-generation costs at 56 per cent. Monetization of utility loss and other costs (spoilage costs, income foregone in household economic activity, etc. each account for 22 per cent.

For lower income households, the share of monetization of utility loss is higher at 44 per cent because a low proportion of such households have either a generator or an UPS. As opposed to this, the share of self-generation costs for the highest expenditure households is high at 74 per cent.

The burden of outage costs as a percentage of total consumption expenditure by a household is given in Table 11. It appears that the highest burden is on the 'middle class' living in the cities of Pakistan. It is 7 per cent for such households as compared to 6.2 per cent for low income households and 5.8 per cent for the richest households.

Table 11
Total Outage Cost as Percentage of Total Household Consumption Expenditure

(000Rs)

	Annual Outage Cost	Annual Consumption Expenditure	Outage Costs % of Consumption Expenditure
0 – 15000	8.8	142.5	6.2
15001 – 35000	21.5	305.9	7.0
35001 – 70000	43.8	627.6	7.0
70001 and above	75.2	1293.9	5.8
Total	**30.9**	**461.1**	**6.7**

Table 12 indicates the total outage cost per kwh for residential consumers on average is close to Rs 24 (25 cents) per Kwh.

Table 12
Total Outage Cost per kwh to Residential Consumers

(Rs)

	Total Outage Costs	Electricity not provided (Kwh)	Outage Cost per Kwh (Rs)
By Location			
Punjab	29229	1655	17.66
Sindh	33317	830	40.14
K-PK	34059	865	39.37
Balochistan	29458	1474	20.00
By Income Group			
0 – 15000	8780	479	19.32
15001 – 35000	21518	732	29.40
35001 – 70000	43798	1599	27.39
70001 and above	75192	4299	17.49
Total	**30865**	**1289**	**23.94 (25 c)**

The highest outage cost per Kwh is observed in Sindh at Rs 40 (42 cents) per Kwh, while the lowest cost is in Punjab at Rs 18 (19 cents) per Kwh. The outage cost per Kwh is the highest for the `middle class` at Rs Rs. 27 (28 cents)- Rs 29 (30 cents).

Blowing-up of the sample to arrive at a national estimate requires, first, estimation of the number of urban households in the country. According to the PES the population of Pakistan in 2011-12 is 180.7 million, out of which 37.4 percent is located in the urban areas. The average household size is given in the latest HIES of the PBS at 6.19. This implies that there are 10.9 million urban households in the country.

Second, there is need to determine the distribution of urban households by level of monthly consumption expenditure. This has also been derived from the HIES and is presented in Table 13.Overall, **the total outage cost to residential consumers in the urban areas of Pakistan is Rs 195.8 Billion in 2011-12.**

Table 13
National Estimate of Outage Costs to Urban Residential Consumers, 2011-12

Monthly Total Consumption Expenditure Group(Rs)	**Number of Households (000s)[a]**	**Outage Cost per Household (Rs)**	**Total Outage Cost (Rs billion)**
0 – 15000	5014	8780	44.0
15001 – 35000	4360	21518	93.8
35001 – 70000	763	43798	33.4
70001 and above	327	75192	24.6
Total	**10464[b]**		**195.8**

[a] adjusted on the basis of distribution in the HIES, 2010-11
[b] 10.9 million households in urban areas with 98 percent of households having access to electricity according to PSLSMS, 2010-11

6. CONCLUSIONS AND POLICY IMPLICATIONS

We have highlighted in the previous section the principal findings on the incidence of outages and cost of load shedding in the residential sector. In this concluding section we derive the key policy implications.

The estimated impact of outages on households is as follows:

(i) Outages on the average occur almost five times a day for 17% of the time. The highest incidence is in Punjab at 1683 hours annually, 16% above the national average. The lowest incidence is in Sindh at 23% below the national average.
(ii) Outages are disruptive most of heating/cooling, household activities, preparation for work/study (especially by children) and any home-based economic activity.

(iii) The outage cost per kwh works out as Rs 24(25c).

Table 14 presents the total cost of electricity consumption to household at different levels of total consumption expenditure (proxy for income). Overall, this is estimated at close to 17%. A striking finding is that the cost is the lowest for the upper most income group.

In the pre-loadshedding period, in 2005-06, according to the HIES, the share of electricity cost in total consumption expenditure was 5% on average for urban households. Following the high levels of loadshedding this share has jumped up by over three times.

TABLE 14
Total Cost of Electricity Consumption Per Residential Consumer

(Rs in 000)

Monthly Expenditure Group(Rs)	**Annual Electricity Cost**		**Annual Consumption Expenditures**	**Total Electricity Cost as % 0f Consumption Expenditure**
	of Public Supply	**Total Outage Cost**		
0-15000	15.3	8.8	142.5	16.9
15001- 35000	28.8	21.5	305.9	16.4
35001-70000	65.1	43.8	627.6	17.4
70001 and above	130.6	75.2	1293.9	15.9
Total	**46.7**	**30.9**	**461.1**	**16.8**

It is clear that the high share of expenditure on electricity is cutting into consumption of food, clothing and basic services (like education and health), especially by the low income groups. As, such an indirect impact of the high level of load shedding in the country is the reduction in nutrition levels, particularly of children. Along with impact on preparation for school and home work, the impact of outages on children needs to be more strongly highlighted.

Overall, limits of affordability to power tariffs have been reached by bulk of the households and the scope for further enhancement in tariffs is very limited. The recent increase in tariffs will put a large burden, especially on the middle class.

Table 15
Present Tariff Structure on the Residential Sector

(Rs)

	Actual Per kwh	Proposed Per kwh
Up to 50 units	2.00	2.00
For consumption exceeding 50 units		
1 – 100 units	5.79	5.79
101-200 units	8.11	8.11
201-300 units	8.11	12.09
301 – 700 units	12.33	16.00
Above 700 units	15.07	18.00

The prevalence of self-generation is relatively low among residential consumers. 28% have generators and 30% have UPS. Resort to self-generation is the highest is Sindh and K-PK and among consumers in the highest income category.

The average capacity of generators in use is under 3.5 KVA. The proposal for eliminating the GST on small generators and UPS is justified in this case also, as for commercial consumers.

Based on responses by the sample households, the following proposals are presented for reducing the level of outage costs:

(i) The majority, 65%, of respondents prefer, given the total duration of loadshedding, shorter though more frequent outages. Higher duration of a typical outage is one of the main reasons why outages costs are higher in Karachi, despite lower incidence of outages.

(ii) Bulk of the loadshedding is in the morning from 6:00 am to 9:00 am. This creates disturbance in preparation for work/school and heating during winters. Over 43% of sample households report that changing loadshedding times to later in the day would be less disruptive, especially to low income households.

(iii) The worst time in year for load shedding is summer and worst day are Sunday, Monday and Friday. To the extent there is scope, the pattern of loadshedding needs to be adjusted accordingly.

(iv) There has been a clear vote of non-confidence against the services provided by the power sector. 43% rate the quality of services as ‘very low’ and 35% as ‘low’. Distribution companies, in particular, will have to work very hard to rehabilitate their image.

(v) A series of recommendations have been made for reducing the costs of loadshedding, as follows,

Construct New Dams	43%
Build New Power Plants	27%
Import Electricity	22%
Minimize Electricity Theft	17%
Stop Corruption	17%
Use Coal	14%
Gas Pipeline From Iran	15%
Subsidy	13%
Reduce Price	10%
Solar Energy	8%

Therefore the largest responses relate to enhancement in electricity supply and to improved management of power sector. Overall , power outages have become a major source of inconvenience and cost to domestic consumers in Pakistan.

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