

An Estimation of the Impact of Uninterpretable Power Supply Systems on Electricity Distribution Utility of Pakistan

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Abstract: The power crisis in Pakistan is getting worse day by day. Electricity shortfall has reached upto 5000 MW. Due to power shortage consumers are facing load shedding for more than 6 hrs a day. To get rid of this crisis consumers have opted fossil fueled generators and UPS. Due to excessive availability UPS are more popular than generators. Although, UPS satisfy the need of consumers during power outage hour but due to efficiency constrains these UPS put extra burden on grid. This study estimates the power loss that occurs in consequence of using inefficient UPS. It has been found that about 3.75% of total power provided by the utility is lost during charging and discharging. The research also provides suggestions to eradicate the efficiency losses which occurred as a result of using UPS.

Keywords: Efficiency, Pakistan, Power Crisis, UPS.

INTRODUCTION

Power sector of Pakistan is confronted with severe electricity shortage since long. The electricity shortfall has increased up to 3000MW – 5000MW which resulted in unscheduled blackouts for 8-12 hours daily [1]. This shortfall has adverse effects on economy as number of industries are shifting to other countries of the region. Similarly, due to power shortage house hold consumers are also frustrated. There have been several technical and administrative reasons, which account for this shortfall. These issues include deficient electricity generation capacity and inefficient electricity distribution [2]. During initial years of electricity crisis the consumers managed the crisis with patience. But with increasing shortfall the consumers opted for various available options to meet their energy needs. These options included use of fossil fueled electricity generators or uninterrupted power supplies (UPS). Due to flexibility in utilization of UPS many of the consumers opted for UPS rather than using electricity generators. There is vast variety available in UPS with varying specifications and prices. The optimal efficiency of UPS range between 93-95% [3]. The efficiency of UPS is purely contingent with attached load, nature of battery, inverter and its utilization pattern. Some UPS have even higher efficiencies due to the use of high tech electronic components in their assemblies [4].

In Pakistan, there is wide range of UPSs available. The UPS vary in brand on the basis of price and specifications. Both local and imported genre of UPSs

are available in every major electricity market of the cities. Due to severe electricity crisis UPS is widely used in Pakistan by domestic consumers and small commercial consumers. The ultimate utilization of UPS is to get the access of electricity during power outage hours of the day. Depending upon storage battery, inversion and charging /discharging losses, the efficiency of these UPSs also vary significantly [5]. However, these UPSs satisfy the consumer needs fairly, even with deteriorated efficiencies. Moreover, most of the consumers are unaware of the inefficiencies of UPSs. The inefficiency of UPSs accumulates and results in extra load on respective electricity distribution utility.

The purpose of this study is to examine the impact of using inefficient UPSs on electricity distribution utility in Pakistan. For the purpose six different UPSs of different make were tested in context of efficiency. The impact of inefficient UPSs was examined on Islamabad Electric Supply Company (IESCO), which is electricity distribution utility of capital city. Based on single distribution utility the study also estimated the impact of inefficient UPSs on national grid.

POWER SECTOR OF PAKISTAN

Power sector of Pakistan is operating under single buyer electricity model in which a single market operator i.e. National Transmission and Dispatch Company (NTDC) purchases electricity from different public and private sector power plants. Public sector power plants include thermal based electricity Generation Companies (GENCOs) and hydel units of Water and Power Development Authority (WAPDA). Currently there are four GENCOs and nineteen hydro

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power stations. Private sector power plants generate electricity through Independent Power Plants (IPPs). Apart from this nuclear(public) and renewable energy resources (private) also contribute in the grid but have insignificant share. The total installed capacity of power sector is approximately 22797 MW. Off the total installed capacity, the share of IPPs is 40% which is followed by WAPDA and GENCOs with 31% and 28% respectively. Other resources which include nuclear and renewable resources contribute 1% only. In the context of contribution of energy to the national grid, the share of IPPs is 49% followed by WAPDA and GENCOs with share of 35% and 15% respectively. Overall the electricity generated through hydro based power plant is 34% which is followed by furnace oil and natural gas with 32% and 23% respectively. The contribution of HSD, nuclear, coal and solar is 4%, 6%, 1% and 2% respectively. It is clear from these statistics that power sector of Pakistan has inefficient fuel mix. Most of the electricity is generated through thermal based fuels which include Furnace Oil (FO), High Speed Diesel (HSD), Natural Gas (NG) and Coal. It is also pertinent to mention that even in the presence of huge hydel potential power sector is dominated with thermal generation [6]. All the electricity generated by these resources is purchased by NTDC which further sell this electricity to ten regional Distribution Companies (DISCOs). These distribution companies are state owned utilities with regional autonomy in geography and operations [7]. The overall power sector is regulated by National Electric Power Regulatory Authority (NEPRA) [8].

Alternative Solution to Power Crisis

It has been now two decades since the development of power crisis in Pakistan. The major issues of the crisis is power outage for long hours and deteriorated quality of electricity supply. During early years of crisis, the electricity consumers managed with

electricity shortages. However, continuous increase in power outage duration triggered consumers to look for other options. These options include fossil fueled electricity generators and UPSs. Keeping in view of power crisis, the marketers also tried to satisfy the consumers need. Initially few brands of generators and UPSs were available. With the passage of time the number of generators and UPSs brand increased. Currently, generators are imported from different countries which include China, Germany, Thailand and India. On the other side the production of UPSs also started in Pakistan as well. Several brands of UPSs are available in market with different prices and specifications. Keeping in view the demand of UPSs, some vendors have started UPS production in local markets as well. Initially, consumers opted generators as an alternative resource but due to increased prices of petrol/ diesel, consumer shifted from generators to UPSs. Figure 1, shows the results of a survey about the trends of consumer behavior for opting alternative resources of power for past few years. For the survey 1500 consumers were selected from electricity distribution utility i.e. IESCO.

It is clear from Figure 1, that the percentage of opting alternative option have changed significantly. Initially in 2005 (early period of power crisis) 42% of consumers surveyed did not opt for alternative power source. Whereas, 30% consumers were found using electricity generators. At that time only 19% consumers were using UPS. The reason for less utilization of UPS also include the availability and awareness of that technology in Pakistan. Very few consumers were utilizing both resources for power supply during power outages. According to the survey by Alternative Energy Development Board (AEDB) in 2010, the percentage of UPS users increased significantly from 19% to 45% which shows that consumers satisfaction with the use of UPS as compared to generator. The percentage of consumers which were found using generators reduced

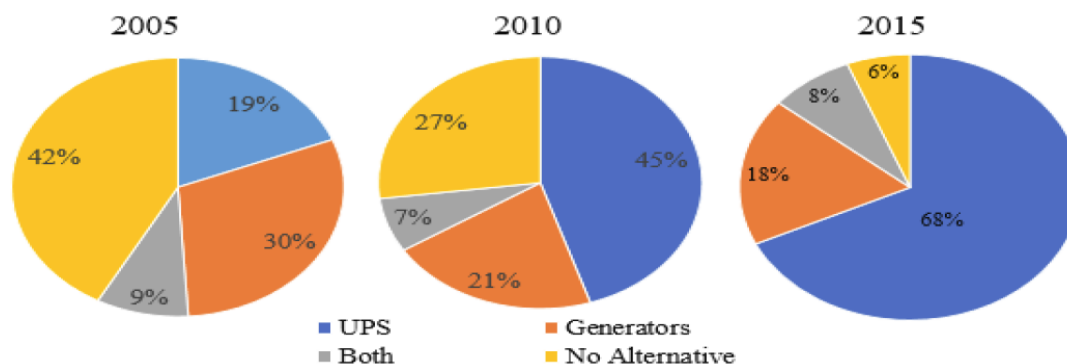


Figure 1: Survey results of power alternative options.

to 21% due to increased prices of fuel. Similarly, in 2015 the percentage share of consumers using UPS has further increased as compared to previous years. The use of generator is also diminishing due to the access availability of inexpensive UPS in the market.

Uninterrupted Power Supply(UPS)

UPS is the combination of electrical devices that serve as a backup during power outage. The conventional UPS consists of a battery and an inverter. The purpose of battery is to store charge during the period in which power supply is available whereas inverter act as voltage convertor that is conversion from Direct Current (DC) to Alternate Current (AC) and vice versa. Figures 1 and 2 shows the working of UPS under both conditions i.e. during power outage period or under/over power and during the availability of AC power respectively.

It is clear from Figures 2 and 3 that the operation of UPS is flexible as compared to electricity generator as it automatically starts working when AC supply from grid shuts down. Similarly, it also provides protection to selective appliances against any voltage drop. The duration of supply of power during shut down period totally depends on nature of storage battery.

UPS and Batteries

In Pakistan, there are several types of UPSs which are available with different specifications and price ranges. According to a survey, there are more than 28

companies whose UPSs are available in market. Apart from these there are local vendors too, who also manufacture UPS using traditional methods. There is a significant price difference between local made UPS and branded UPS. Similarly, there are number of brands which manufacture batteries as a backup storage for these UPS. It is interesting to mention that in Pakistan instead of deep cycle gel batteries, lead acid batteries are used extensively with UPS. Technically, lead acid batteries are designed for startup of vehicles. This can be justified by the fact that these batteries are inexpensive and easily accessible in the market. According to a survey, there are only 2 companies which import deep cycle gel batteries for commercial UPSs.

METHODOLOGY

In the context of existing power crisis, the purpose of this study is to examine the impact of utilization of UPS on the electricity distribution utility. To achieve the purpose, we have selected six famous brands of UPS. Among these six brands, three are locally manufactured whereas other three are of Chinese brand. The power rating of each of these six brands is approximately 1kVA. The methodology adopted for efficiency measurement is quite simple which utilize back up time as an efficiency indicator. These UPS are charged from national grid to full extent and then connected to the equal load. Discharging time of battery that is back up time is then calculated for each case. Technically, it is the difference of power (kWh)

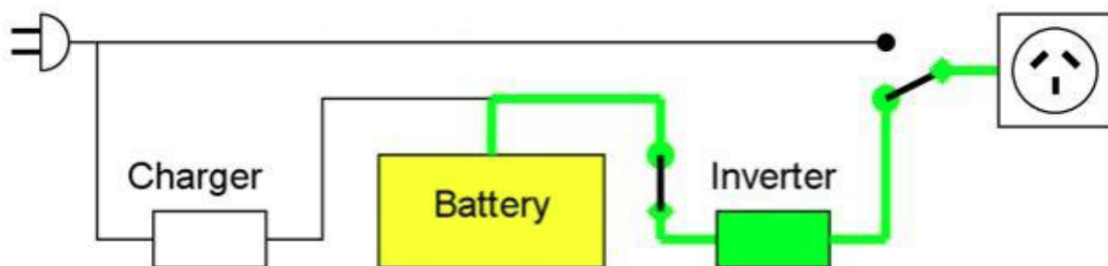


Figure 2: Working of UPS during unavailability of AC or in over/under AC power.

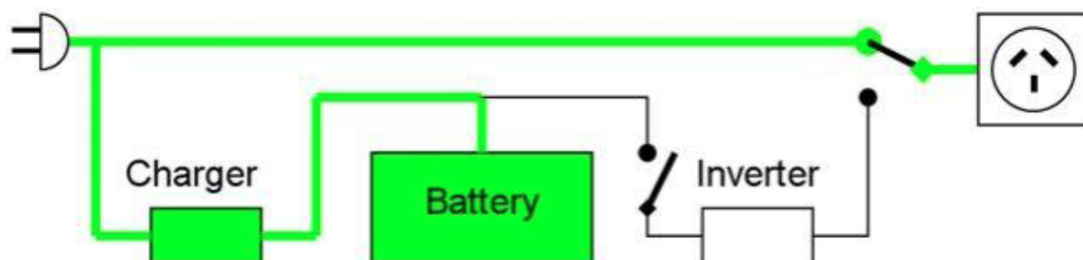


Figure 3: Working of UPS during availability of AC.

used for charging the battery and power (kWh) delivered as output in each case. The method for examining the impact involved three steps.

Step#1: Efficiency Testing (Ideal Conditions)

For the analysis purpose the individual efficiency of inverter and battery without load is assumed to be the same for each case. Table 1, provides the efficiency of 6 different types of UPS under the attached load but in ideal condition that battery is completely charged and then discharged.

Table 1: Efficiency of UPSs

UPS Type	Battery Type	Load	Efficiency (%)
1	12 V	200 W	53.8
2	12 V	150 W	56.2
3	12 V	120 W	49
4	12 V	120 W	51.2
5	24 V	250 W	58.1
6	24 V	280 W	57.08

It is clear from Table 1, that the maximum observed efficiency is of UPS#5 which is 58.1% with load of 250W and 24V battery. Similarly, the minimum observed efficiency is of UPS# 3 which is 49% with load of 120W and 12V battery. It has been further observed that the average efficiency of UPS is 54.23%. The average value of efficiency is quite less as compared to that defined by which is 94% [3]. The reason of this deteriorated efficiency is inefficient components used in inverters. Similarly, lead acid batteries also affect the effectiveness of the UPS.

Step#2: Efficiency Testing (Real Conditions)

In previous section the efficiency of UPS was evaluated individually with an assumption of full charging and then complete discharging. On real grounds, it happens very rarely that a UPS completely discharge. Table 2, provides the charging efficiency of

Table 2 Efficiency of UPSs under Real Conditions

	Load					Average
	45%	55%	65%	75%	85%	
Per Hour	0.16	0.2	0.24	0.28	0.32	0.24
Per Day	1.28	1.6	1.92	2.24	2.56	1.92
Per Month	38.4	48	57.6	67.2	76.8	57.6

the same set of UPS based on 45%-85% battery exhaustion. For the analysis purpose, it was supposed that the average efficiency is 54.23% and the normal average load is 0.670kW. Furthermore, the capacity of UPS was assumed to be 1 kVA.

It is clear from Table 2 that on average 1 kVA UPS with 0.670kW load with 1 hour of power outage wastes 0.24% energy. On daily basis with 8 hours of power outage the same UPS wastes 1.92% of energy. Based on same calculation on monthly basis the same set of UPS wastes approximately 57.6% of energy.

Step#3: Impact on utility

To estimate the impact of utilization of UPS on electricity distribution utility we used the results of efficiency measures on one of the most important electricity distribution utility that is IESCO. The geographic jurisdiction of IESCO include the capital city of Islamabad and Rawalpindi. IESCO jurisdiction is expanded to total area of 23,160 sq. km and it facilitates total number of 2.26 million consumers (Domestic, Commercial, Industrial, Agriculture, Public Lightning, Bulk Supply and others) [9]. Total peak demand of IESCO is 2087 MW. The details of IESCO is presented in Table 3.

The total number of consumer of IESCO are 2462167 of different consumer categories. Out of the total consumers the number of domestic consumer is 2085256 which is 84% of the total consumers. It is evident from this fact that the distribution utility is dominated by domestic consumers. It can further be concluded that most of the users of this electricity distribution utility are utilizing UPS as an alternate source. Table 4 provide the percentage of consumers and the consumption patterns.

From Table 4 it is clear that, approximately 80% of household users consume more than 100kWh. Relating it to the previous assumption that around 60% of domestic consumers use UPSs which means that more than 700000 domestic consumers have UPS of 1kVA in IESCO area. Table 5 provides statistics of

Table 3 Details of Islamabad Electric Supply Company (IESCO)

Category	Domestic	Commercial	Industrial	Agriculture	Public Lighting	Bulk Supply	Others	Total
# of Consumers	2085256	350989	15048	8192	1674	968	40	2462167
Sanctioned Load	3723	1043	970	89	99	483	290	6698
Energy Sold	3704	844	1671	93	76	1755	4	8147
% Revenue Recovery	99.49	99.4	99.5	99.48	100	61.7	100	90.91
Annual Energy Cons.	1776	2405	111045	11353	45400	1813017	100000	3000
Distribution Losses	9.41%	No. of 11 kV Feeders	965	# of Power Transformers	168(132kV)	10(66kV)	7(33kV)	185 kV

Source: NEPRA State of the Industry Report 2016-17.

power wasted by UPS in IESCO under different loads and for number of power outage hours.

Table 4: % Age of Consumption Pattern Electricity

Utilization of Power (Kwh)	%age of Consumers
50 or less	3.1
50-100	18.8
101-300	58.0
301-1000	14.0
1001 or more	7.0

Source: NEPRA State of the Industry Report 2016-17.

It is clear from Table 5 that on average 0.24 kWh of energy is wasted in case of one hour of power outage.

Similarly, for the power outage of 12 hours 2.88kWh is wasted daily by using a single UPS. The Table 5 also show that on monthly basis the wasted energy range from 7.2kWh to 86.4kWh for 1hr to 12hr of power outage respectively. Similarly, it can be estimated by using the approximate number of UPS being used by domestic users of IESCO. As estimated previously that 30% of total domestic user are 625577. On the basis of consumers Table 6 provide the overall wasted energy by UPS in IESCO.

From Table 6 it is clear that with 1hr of power outage the amount of energy wasted for IESCO is .15 Million kWh. Similarly for 8 hrs of power outage the amount of energy wasted is 1.2 Million and for 12 hrs of power outage the amount of energy wasted is 1.8 Million. It has been estimated that the total

Table 5: Efficiency Test of UPS in IESCO under Different Loads and Number of Power Outage Hours

# of Hours	Load					Average Wastage	Monthly Wastage
	45%	55%	65%	75%	85%		
1	0.16	0.2	0.24	0.28	0.32	0.24	7.2
2	0.32	0.4	0.48	0.56	0.64	0.48	14.4
3	0.48	0.6	0.72	0.84	0.96	0.72	21.6
4	0.64	0.8	0.96	1.12	1.28	0.96	28.8
5	0.8	1	1.2	1.4	1.6	1.2	36
6	0.96	1.2	1.44	1.68	1.92	1.44	43.2
7	1.12	1.4	1.68	1.96	2.24	1.68	50.4
8	1.28	1.6	1.92	2.24	2.56	1.92	57.6
9	1.44	1.8	2.16	2.52	2.88	2.16	64.8
10	1.6	2	2.4	2.8	3.2	2.4	72
11	1.76	2.2	2.64	3.08	3.52	2.64	79.2
12	1.92	2.4	2.88	3.36	3.84	2.88	86.4

Source: Data obtained from DISCO.

Table 6: Overall Efficiency Test of UPSs in IESCO under Different Loads and Number of Power Outage Hours

# of Hours	Load					Average Wastage
	45%	55%	65%	75%	85%	
1	100092	125115	150138	175162	200185	150138
2	200185	250231	300277	350323	400369	300277
3	300277	375346	450415	525485	600554	450415
4	400369	500462	600554	700646	800739	600554
5	500462	625577	750692	875808	1000923	750692
6	600554	750692	900831	1050969	1201108	900831
7	700646	875808	1050969	1226131	1401292	1050969
8	800739	1000923	1201108	1401292	1601477	1201108
9	900831	1126039	1351246	1576454	1801662	1351246
10	1000923	1251154	1501385	1751616	2001846	1501385
11	1101016	1376269	1651523	1926777	2202031	1651523
12	1201108	1501385	1801662	2101939	2402216	1801662

consumption of IESCO user for 24hr is 48Million kWh. It means that 3.75% of the electricity can be utilized for other purposes is wasted.

CONCLUSION

In this research impact of excessive use of UPS in electricity distribution utility has been examined. It has been found that the inefficient UPS has adverse effects on electricity distribution utility in terms of energy wasted in charging and discharging of UPS. The main cause of inefficiency is use of lead acid battery instead of gel batteries. Similarly, the use of inexpensive local made UPSs also affect the efficiency during charging and discharging of a battery. It may further be concluded that to avoid from these losses, policy incumbents have to readily resolve the issue of power shortage. This is the longterm solution, however the short term suggested solution is to pave the way for manufacturing deep cycle gel batteries and quality UPSs. Moreover, a policy may be devised to promote the use of solar panels for charging of UPS so that losses can be minimized on electricity distribution utility.

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