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Cost Benefit Analysis of Smart Metering

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***Abstract*—**Traditionally electricity is generated near bulk storage of a resource and then transmitted to far flung areas through long and lengthy transmission lines. Thisenergy in the next phase is distributed to consumers. A fraction of electric energy lost in reaching customer's premises is known as T&D or technical losses. Another fraction of energy lost due to electricity theft by consumers and due to errors in calculation by utility operators.These lossesare also known as commercial, non-technical and administrative losses. In Pakistan and other third world countries an enormous amount of energy is lost due to electricity theft. The portion of energy lost as unpaid back to utility causes a huge economic loss to utilities and hence the whole energy sector. The traditional electromechanical energy meter are not sufficient enough to sense and control electricity theft. The deployment of Advanced Metering infrastructure is inevitable to mitigate and control losses due to theft and it also provide exact ratio of energy used and lost.

***Keywords*—** Aggregate Technical and Commercial losses, Peshawar Electric Supply Company, T & D losses, Head End System, Advanced Metering Infrastructure.

I. INTRODUCTION

Losses in electricity supply to consumer means the difference of electric energy injected to transmission/ distribution grids and the fraction of electric energy not paid back. Total losses have two components, i.e. Technical losses and Commercial Losses. Technical losses are mainly due to power losses in electricity system components, i.e. losses in transmission and distribution lines, transformers and measurement systems. These losses are also named as T & D losses. Non- Technical losses are not because of internal faults in the system but due to intruders such as electricity theft, and non-payment by consumers and error in record keeping and calculations. They may be known as commercial losses and administrative losses [1]**.** Figure 1 below shows the scenario of T&D losses in Pakistan for the duration of 1997 to 2015.

The amount of technical and commercial losses and economic loss to utility (PESCO) due to electricity theft is presented in Table 1. Figure 2 also shows the amount of losses and collection Efficiency Index in ShahiBagh feeder.

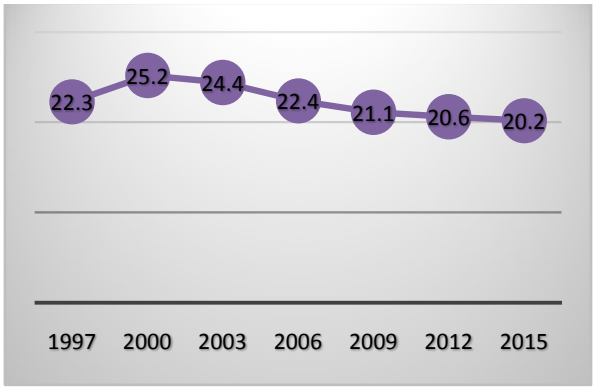

Figure 1. T & D losses in Pakistan [5].

Total losses = AT & C losses (1)

Non-Technical losses= AT & C losses – Technical losses (2)

For example

Name of 11 kV Feeder: ShahiBagh

Technical losses (Progressive Aug and Jul 2016) = 32.60

AT & C losses (Progressive Aug and Jul 2016) = 44.53

Non-Technical losses= 11.93

As Total loss= 44.53

Then 11.93 is 27^{th} fraction of the total losses.

It means that 27^{th} fraction of total units lost due to Non-Technical losses.

Total lost units for progressive years (Aug and Jul 2016)

= Units Injected – Units paid back
= 390767351– 321598703
= 69168648

27^{th} fraction of lost units (commercial loss) = 18675534.96

Now the total economic loss due to Non-Technical losses for progressive months ofAug and Jul 2016 = 20 × 18675534.96

= 373.5 M PK

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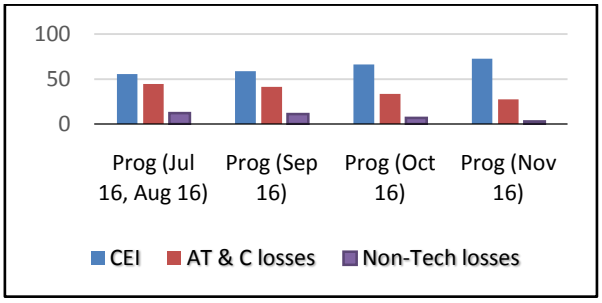

Figure 2. Non-Technical/Technical Losses and CEI in ShahiBagh Feeder

II. ADVANCE METERING INFRASTRUCTURE

Non-Technical losses are evitable financial loss for utilities and there is a need of calculation of exact amount of these losses to tackle the issue. Smart Meters provides exact amount of energy lost due to Non-Technical losses. Rani et al. proposed Advanced Metering Infrastructure (AMI) model for Metropolitan cities of Pakistan i.e. Lahore and Karachi. Smart Meter collects the data of energy utilized by electrical equipment of the consumers and sends real time data to central system through cellular communication system. Head End System (HES) at utility center constantly auto monitor the data of consumers and when there is pilferage the data received at the substation is not like normal data and the customer is warned and stressed [2]. EPRI and India Smart Grid Forum performed cost benefit analysis of Smart metering and found the per customer costs of smart meters for residential, commercial and industrial customers [4].

Figure 3. Smart Meter [6]

A. *Cost Benefit Analysis of AMI rollout in ShahiBagh Feeder*

The ShahiBagh feeder is selected to study its AT & C losses and Advanced Metering Infrastructure is considered as an ultimate solution to mitigate these losses. The purpose of the AMI deployment is to cater the power system with an exact data about energy consumption which makes it easier for the caretakers of the power sector to make proper arrangements for other issues in the power system. The Cost Benefit ratio for AMI rollout in ShahiBagh feeder is presented but it is necessary to be kept in mind that it is an estimated Cost Benefit Analysis.

TABLE I. AT & C AND OTHER LOSSES FOR SHAHIBAGH FEEDER

Month	Asst	Paymt	Losses	ATC
Jul 16	253760307	158431337	30.70	56.73
Aug 16	137007044	163167366	35.20	22.83
Prog:	390767351	321598703	32.60	44.53
	Economic Loss		PKR. Million	373.5
Sep 16	139858473	124809550	23.20	31.46
Prog:	530625824	446408253	30.00	41.11
	Economic Loss		PKR. Million	454.7
Oct 16	103626739	130100622	11.80	-10.73
Prog:	634252563	576508875	27.00	33.6
	Economic Loss		PKR. Million	80.8
Nov 16	47371590	77641423	-1.20	-65.87
Prog:	681624153	654150298	24.40	27.4
	Economic Loss		PKR. Million	60.4
Dec 16	43523328	47927946	21.50	13.6
Prog:	725147481	702078244	24.20	26.61
	Economic Loss		PKR. Million	41.5
Jan 17	42809797	52240347	40.20	27.0
Prog:	767957278	754318591	25.70	27.02
	Economic Loss		PKR. Million	13.6
Feb 17	54199721	52204924	16.50	19.6
Prog:	822156999	806523515	25.10	26.52
	Economic Loss		PKR. Million	15.6
Mar 17	52276710	50322846	9.80	13.17
Prog:	874433709	856846361	24.10	25.63
Economic Loss for selected time frame			PKR. Million	21.1
Total Economic Loss in 10 Months			PKR. Million	1061.4
Economic loss in one year			PKR Million	1592.2

B. *Installation Cost of Smart Meter at customer premises*

The total number of registered customers with ShahiBagh feeder are 24000. Statistics about the installation costs at customer end are presented in Table II.

TABLE II. INSTALLATION COSTS OF SMART METER AT CUSIOMER PREMISES [3].

Item	Unit Cost (PKR)	Quantity	Total Costs (PKR)
Smart Meter with Communication Module	4,860	24000	116.6 Million
Meter Box	810	24000	19-4 Million

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Installation Charges	810	24000	19.4 Million

C. Cost for Communication Infrastructure

The data communication between electrical equipment at houses and smart meter is done through RF mesh of Local Area Network (LAN) while the data from smart meters to Head End System is sent through existing cellular communication infrastructure. Table III shows total costs for the installation ofcommunication infrastructure necessary for data communication.

TABLE III. INSTALLATION COST OF LOCAL AREA NETWORK FOR SHAHIBAGH FEEDER [3].

Item	Unit Cost (PKR)	Quantity	Total Cost (PKR)
Data Concentrator Unit (DCU)/ Gateway	80,000	240	19.2 Million
Installation and setting up of RF mesh network	8000	120	0.96 Million
Total	88000		20.16 Million

D. System Cost

The system cost is the cost of the system for integration of smart meters data. It is installed to control and integrate the data from customers of the whole utility which is PESCO in this case. Table IV shows the cost of installation of integration system for PESCO and also per feeder in the last.

TABLE IV. HARDWARE AND SOFTWARE SYSTEM INSTALLATION AT PESCO LEVEL [3].

Items	Unit Cost (PKR)	Quantity	Total Cost (PKR)
Head End System (HES)	32400000	1	32.4 Million
Meter Data Management System (MDMS)	32400000	1	32.4 Million
Computer Hardware & System Software & Networking System	81000000	1	81 Million
System Integration	81000000	1	81 Million
Total Costs (PKR)		226.8 Million	
Cost per feeder		2.09 Million	

E. Operation & Maintenance Cost

Operation and Maintenance cost include system running costs of the whole Smart Metering infrastructure. Some system are to be installed at the utility level but finally cost per feeder level also calculated. Table V presents the O&M costs of the AMI Infrastructure.

TABLE V. O&M COSTS OF SMART METERING INFRASTRUCTURE FOR SHAHIBAGH FEEDER [3].

Item	Annual Cost (PKR)	Life Cycle	Total Life Cost (PKR)
Annual Maintenance Charges of Smart Meters at 2.5 per annum	3888000	10 Years	38.88 Million
Annual Maintenance Charges of Head End System (HES) at 20%	6480000	5 Years	32.4 Million
Annual Maintenance Charges of DCU @ 2.5 p.a.	480000	10 Years	0.48 Million
Annual Maintenance Charges of Meter Data Management Systems (MDMS) at 20% p.a.	6480000	5 Years	32.4 Million
Application Maintenance Support of MDMS and HES at 10% p.a.	6480000	5 Years	32.4 Million
O & M for attending to repairs/ replacements/ customer complaints/ up gradation	2400000	10 Years	24 Million
Charges for Communication System (LAN/GPRS)	240000	10 Years	2.4 Million
Total Costs		162.96 Million	
Costs per feeder		65.8 Million	

F. Benefits of Advance Metering Infrastructure

The Benefits of smart metering comprises of both extra benefits of AMI as compared to traditional metering and also savings to reduce the existent losses. Table VI shows the detailed of AMI rollout.

TABLE VI. BENEFITS OF AMI ROLLOUT [3].

Benefits	Value	Annual Savings/ Benefits for selected feeder
Annual Savings on meter reading costs (salary, allowances and travel costs of meter readers, stationary, etc.)	PKR 25 per customer per month considered. =25*12*24000 per year.	7.2 Million
Annual savings on data entry cost for bill generation	PKR 12 per meter read per bill = 12*12*24000	3.45 Million
Annual savings on cost for disconnections/ connections	Disconnect/ Reconnection is considered for 1% customers every month and cost considered as PKR 800. =800*12*240	2.3 Million

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Annual savings due to detection of dead meters	No. of dead meters considered for 0.1% customers =24*12*20	0.005 Million
Annual savings due to reduction in AT & C losses	Non- technical losses controlled due to smart metering.	1592.2 Million
Annual Saving due to reduction DT failure	5% reduction is considered due to AMI, 96 DT considered for selected feeder, PKR 162000 for each DT 5% of 96*162000	0.77 Million
Annual savings due to reduction of load during peak hour	20% load reduction at peak hours & energy input cost difference of 3.24/kWh considered.	4.14 Million
Total Savings/Benefits	1610.09 Million	Total Savings/Benefits

G. Cost Benefit Ratio

Cost to benefit ratio shows the ratio of costs to benefits and Table VII presents cost benefit ratio of smart metering.

TABLE VII. COST BENEFIT RATIO OF SMART METERING [3]

Costs	**Benefits**
243.6 Million	1610.09 Million
6.6:1	

H. Sociopolitical Environment in Pakistan

The Sociopolitical environment of Pakistan is the biggest hindrance in the way of Smart Metering to solve the issues of energy theft and other commercial losses. Some of the main issues are as under.

- Low literacy rate and no social awareness against corruption and thievishness.
- Law and order situation in the country is not good.
- Utilities does overbilling to compensate their losses which increase dejectedness in honest consumers.
- There are special punishment laws for energy pilferage and meter tempering but these laws are not applied to criminals.
- The WAPDA technicians helps customers in finding ways to energy theft.
- The government Policies are not customer friendly to increase customer's satisfaction.

CONCUSLION

This paper presents detailed Cost Benefit Analysis for ShahiBagh feeder which operates under the territory of PESCO. The Cost Benefit ratio of Smart Metering clearly depicts that AMI deployment is necessary and advantageous over traditional electromechanical energy meters.

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