Use of AMR and CEI for Load Management due to Power Crisis in Pakistan

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***Abstract*—Pakistan is facing severe short fall in the energy sector since last two decades, which is affecting badly the industrial development and economic growth as well as adds woes and miseries to the lives of the people.In this regard the government has planned various strategies and these are being implemented, in order to resolve the issue of power crises. A beneficial, cost effective method applied, to conserve the electrical energy narrow the gap between demand and supply, is the use of Automatic Meter Reading (AMR) and the Load Data Improvement Program (LDIP). Composite Efficiency Index (CEI) is worked out using two variable factors i.e. line losses of 11KV feeder and its revenue recovery of energy bill amount. In this paper, we have tried to address the issue of electrical power shortage issues in Pakistan in a different aspect. Although the government is trying to address this issue on its own level by constructing more dams but the power shortage may prolong for further few years.**

***Keywords*—Energy Conservation, AMR, Line Losses, CEI**

I. INTRODUCTION

From the day of independence till 1990's the country was self sufficient to meet its electrical energy demand. However with the passage of time, the demand of energy was continually being increased tremendously, in the industrial, commercial and domestic sector, but no major power projects were established after 1980's, which signals the severe power crises to be confronted with the country very soon in the near future [1]. In this regard many factors were contributing in the power crises of the country, such as the failure to construct power houses timely which producing cheap electrical energy, the incapacitated, old and deteriorated transmission and distribution system, to cater the perpetually increased demand, which result into system constraints, poor administrative control (theft of electricity) and weak management on the distribution side [2].

In order to cope with this crucial situation the government, ultimately made a plan and formulated the energy power policy focusing mainly on the development of thermal power sector to meet the energy demand on midterm basis. In this context in 1994 the government inked an agreement with the independent power producers (IPP's) to construct thermal power plants so that to get narrow the gap between the demand and supply.

In Pakistan the electrical power is generated mainly by using mostly non-renewable sources of energy, such as fossil fuels (Furnace oil, Natural gas, Coal) nuclear and renewable sources like hydel, solar, wind power [3]. The government shall needs to focus on it to exploit the potential of other renewable prospective energy sources, such as biogas, geothermal, tidal wave energy, so that to produce the clean electrical energy, which is being more environment friendly [4].

In this regard the government has planned and various strategies being implemented, in order to resolve the issue of power crises. One of the immediate and most cost effective way adopted on short term basis was to conserve the electrical energy by educating, motivating the people by bringing change in their behavior regarding energy consumption, by giving incentives, like two part tariff, subsidized the duties on efficient energy gadgets to industrial, commercial and domestic consumers, enabling them to replace the inefficient energy consumption gadgets with the energy star and efficient one. It is pertinent to note that the energy conservation achieved in this way will required no need of heavy capital investment and long period of time.

In Pakistan mainly the electrical energy is generated by using mostly non-renewable sources of energy, fossil fuels (Furnace oil, Natural gas, Coal) nuclear and renewable sources such as hydel, solar, wind power. The other renewable prospective sources, biogas, geothermal, tidal wave energy which needs the focus of the government to exploit its potential to produce clean electrical energy, being more environments friendly [5].

The country faces severe short fall in electrical power since last two decades and still continue, which affect severely the development and economic growth as well as adds woes and miseries to the lives of people. After 1980 no major development have been done in the field of hydroelectric power sector and ultimately the government made a plan and formulated energy power policy focusing mainly on the development of thermal power sector. In 1994 the government inked an agreement with the independent power producers to

construct thermal power plants to narrow the gap between the demand and supply. The government vigorously peruses the policy of energy conservation, because there is tremendous potential to conserve the energy without being investing huge capital for the installation of power plants, by just adopting the energy conservation measures and replacement of inefficient electrical gadgets with the energy star and efficient one. In this regard to bring about the change in consumers behavior by educating them regarding the importance and necessity of the saving the electrical energy which help both, in the shape of reduction in the demand, and saving in their cost of energy bill amount as well as saving in the national exchequer.

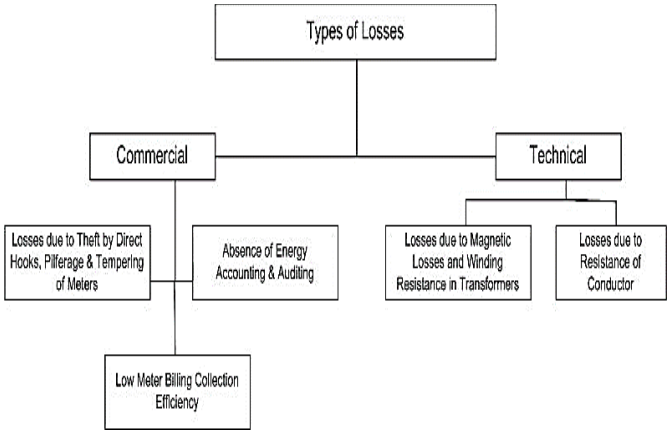

Figure 1: Types of Losses

In the electrical transmission and distribution system the technical Losses occurs inevitably because of the characteristic property of the conductive material. Hence we have to try to keep it at minimum level. To keep it at minimum possible level it is necessary to find out the causes of losses in system and its remedial measures.

There are two types of technical losses i.e. fixed losses and variable losses as shown in figure 1. Fixed losses almost remain same as per change in current. These losses appear in the form of heat and noise. When the transformer is given supply these losses starts to occur. These losses are around 25% to 30% of total technical losses [6].

In the high voltage level transmission system corona losses occurs of which impact must be considered. Variable technical losses in system are mainly due to current opposition by resistivity of conductor and winding material of transformers. Variable losses differ with the amount of current. These losses are directly proportional to square of the current. The percentage of these losses turn around 75 to80 that of total technical losses. We can reduce these losses by increasing the cross sectional area of lines and cables for a given load. These losses are analyzed through Computer Aided Simulations of Distribution Network. Accuracy depends on network operating parameters i.e. Load, Load Factor, System Configuration, Conductor Size, Diversity Factor, Voltage, Frequency, and Length of Line, Transformers and Load Density. At high voltage level the transmission losses are at the lower level comparatively, high quality of power supply with almost no voltage drop, less burn out of motor. Extension of primary distribution line i.e. 11.5KV near to the premises of the consumer and Installation of low capacity single phase distribution transformers according to the load demand of consumer's instead of large capacity transformer feeding numerous consumers, will help in reduce the losses [7].

II. LITRATURE REVIEW

The electricity is an essential commodity in the development and growth of the economy of the country. Electricity considered as a most important factor in production and consumption in the economy around the globe, (IEA, 2005). Demand for electricity is more than the supply of electricity generated in Pakistan. The total power generation capacity of Pakistan in 1947 was 60 Mega Watt (MW) and demand was almost the same. The installed capacity of electrical energy increased with the course of time i.e. in 1970 636 MW, in 1975 1331 MW, in 1980's 3000 MW and in 1990-91 8000 MW. As the population grew up the demand for consumption of electrical energy also increased in all sectors accordingly. During the period of 1960-1980 the main focus of the policy makers was on hydel electricity generation projects but missing the idea of developing the power generation houses using alternatives sources of fuels in order to increase the cheap electricity generation and meet the demand. Resultantly there was gap between demand and supply occurs and the country start facing severe electric power shortages and outages, which has been affecting the lives of people in all sectors as well as slowed down the economic growth of the country [8].

In recent years main focus was made on the construction of thermal power plants with the main source of fossil fuel disturbing greatly the price of electricity in the country because the other alternative generation resources of electricity like hydel and renewable ones ignored miserably. This worst situation in shortfall of electricity and incapacitated power generation system unable to meet the total demand of the country raised because of the sheer lake of vision, commitment and political instability.

The major electrical power producers in the country are Water and Power Development Authority (WAPDA), Karachi Electric (K.E), Independent Power Producers (IPPs), Pakistan Atomic Energy Commission (PAEC). The total installed capacity of power in Pakistan is 22,797 MW in 2016 and with the passage of time the power houses become old and its efficiency, is dropped to almost 17000 MW. During the hot summer season the country faces a shortfall of around 4000MW to 5000MW.

The consumers lack the knowledge about the incentives to use and effectively applied the demand response program. There is another effective tool to response automatically to the incentives is the Home Energy Management (HEM) system. The main feature of HEM program is to minimize consumer

bill amount that will enable consumer to take part actively in the demand response program to make it fruitful [3].

The sustainable socio-economic development mainly relies on a workable future power grid to gain this goal. A properly functioning future power grid will be able to contribute to (i) environmental friendly de-carbonization of energy sources, (ii) improvement in efficiency to process conversion and end user (iii) clean transportation [4].

Many consumers are investors who would have little interest in the electrical energy conservation due to the factors such as ignorance, lack of knowledge about the technical skill of modern technology and its financial impact. The financing issue is another factor which hinders the potential benefit to be achieved in this regard [5].

The Power Distribution Companies (DISCO's) and NPCC/RCC has planned to utilize the existing infrastructure in an efficient and cost effective way by reducing and shifting peak load demand during peak hours by installing Load Data Improvement Program (LDIP) and adopting two part tariff policy for the consumers which resultantly benefit the consumers by conserving electrical energy and saving the cost of bill amount [6].

III. MOTIVATION

Due to the prevailing power crises, since long therefore, the country in general and PESCO in particular, is being facing, huge scheduled and un-scheduled (due to system constraint), power outages (load shedding) for long hours, which has to be carried out to meet the gap between power supply and demand so that to ensure power network system stability, reliability and avoid total blackout and breakdown.

In order to mitigate the severity of the shortfall in electrical energy and to minimize the gap between demand and supply, the government should have planned and framed policies to provide and ensure all the available resources to execute these plans. For this purpose to achieve the goal, there are several plans which are considered and being implemented on top priority basis i.e.

1- Immediate plan
2- Short term plan
3- Medium term plan
4- Long term plan

The problem of power crises needs to be resolved as earliest as possible to bring relief and prosperity in the lives of public and meet the power demand of industry, cost effectively. There are several plans and strategies being considered and under implementation phase, the smart grid approach is one of the best prospective solutions to the problem. The smart grid apply the modern technology to involve and interact the general consumers with the power utilities smartly by diverting the huge energy consumption gadgets operationduring peak demand hours to off peak low tariff zone.

IV. AUTOMATIC METER READING

Conventional meter reading data collected by human is not an efficient way to meet the continuously increasing demand of domestic sector. The automatic meter reading (AMR) system is the solution to this issue which functions in automated mode to record the readings and transmit to the remote control center automatically of all type of consumers such as industrial, commercial and domestic one.

The AMR meters use the communication module which enables it to receive and send the electrical data and other relevant information over the telecommunication network to central system. The AMR meters use one-way communication.

The conventional system had been in use since years needed to be replaced by modern system using the advance technology so that to redress the issues related with the conventional meter reading system. The extensive potential benefit and facility of this modern system cannot be denied either by the utility or the consumers.

V. LOAD DATA IMPROVEMENT PROGRAM

Load Data Improvement program was installed in the Peshawar Electric Supply Company (PESCO) by using the modern technology of Automatic Meter Reading. Its main purpose is to monitor, supervise and control effectively the load management program with interaction of grid substation staff using this technology, in order to minimize un-scheduled load shedding and give relief to the general public and other consumers such as commercial and industrial ones. With the application of this program overloading of power and distribution network system during peak hours is made manageable, ensure stable power flow by avoiding unwanted breakdown, also make ensuring electrical energy conservation and reduced cost of consumer bill amount while carrying out load shedding implementation on the basis of composite efficiency index (CEI).

Advantages of Load Data Improvement Program:

- Minimizing the Technical Losses & Improves the system reliability
- Help Improves the System voltage
- Improves the power factor which results in demand reduction resulting electrical energy conservation.
- Helpful in Preventive Maintenance
- Help to avoid overloading of power transformer and extend its life.
- Reduces billing errors
- Maximize the service confidence.
- Maximize the information about power usage to conserve electrical energy and save money.

The Data received from the AMR meters installed at the 11KV incoming and outgoing feeders as shown in figure 2.

- ❖ AMR meters are installed at the Grid station 11KV outgoing panels,commercial and industrial consumers.
- ❖ From the grid station the meter sends the recorded data over the GPRS, GSM, 3G or 4G LTE, on the availability of each of them, and utilizes the media.
- ❖ The data is then transmitted to the Central Data repository Center at Lahore; the telecom center's

installed MSC (Mobile Switching Centers) at the centre, enable to receive and consolidated the data near to real time for monitoring, control, supervision and analysis.

- ❖ At the Central Data Center , National Operation Center (NOCs) 4 servers are installed which performs the functions.
  - o One Receives the data from the meters installed at the incoming and outgoing feeders.
  - o Second server performs the compilation process.
  - o Third server maintains the database.
  - o Fourth server supplies the data to the different end users i.e. NPCC/RCC, Ministry of Water and Power and Power Distribution Centers at company head quarter level.

❖ Web based application is used to access the server and retrieve the data from the Central
Datarepository Center and is accessed over a static IP internet connection.

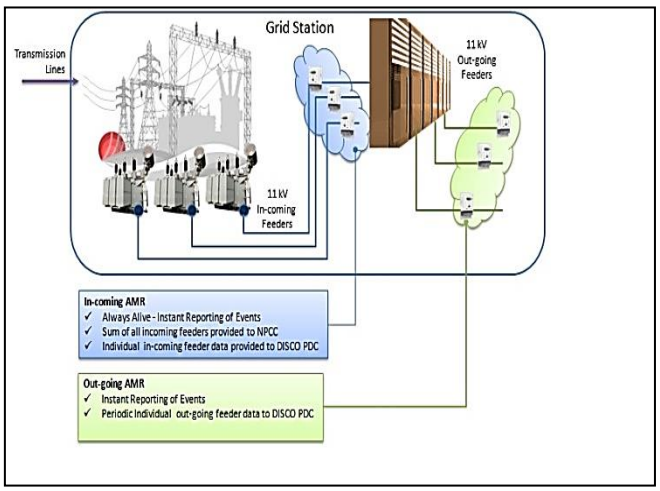

Figure 2: LDIP Architecture

VI. Proposed Methodology

By adopting this modern technology, enables the power distribution company (Discos) to apply CEI (Composite Efficiency Index) based load management plan, on all 11KV feeders for different periods of hours. Feeders having lowest figures of CEI are worst ones in terms of high losses and poor recovery of revenue, facing long duration of load shedding thus enabling to avoid overloading, breakdowns any damage to precious power equipment, ensuring smooth and stable load curve during the peak demand hours ,which results in to reduce the technical/administrative loss in power and distribution network system and ultimately conserves the energy and save the cost of bill amount of consumers and also the national exchequer in million of rupees. Due to power crises there is shortfall in order to meet the gap between supply and demand, load shedding become inevitable. A criterion was needed to be implement load shedding program indiscriminately, which based on reason, for this purpose a formula was worked out.

CEI = Composite Efficiency Index

$$CEI = \frac{(100 - \%age\ Line\ Losses) * \%age\ Private\ Recovery}{100}$$

The feeder lies in the category of 0 – 10 % range of CEI as shown in table 1, which reveals the worst condition in line losses and revenue and therefore the highest number of interruptions of power supply is carried out on this as well as on all such feeders accordingly in order to get narrow the gap between power supply and demand, avoid overloading, breakdown of power network system also result in electricity energy conservation and saving in the bill amount of consumer and the national exchequer during peak hours particularly.

S.No	CEI Category	No of Interruptions Feeders (01-Hour Each)	No of 11KV Feeders
1	0 – 10 %	20	61
2	10.1 – 20 %	20	71
3	20.1 – 30%	16	76
4	30.1 – 40 %	14	61
5	40.1 – 50 %	12	63
6	50.1 – 60 %	6	104
7	60.1 – 70 %	4	104
8	70.1 – 80 %	4	88
9	80.1 – 90 %	4	35
10	90.1 % and Above	0	49
11	Industrial + other Feeders	0	200

Table: 1 CEI Based Load Shedding Slab

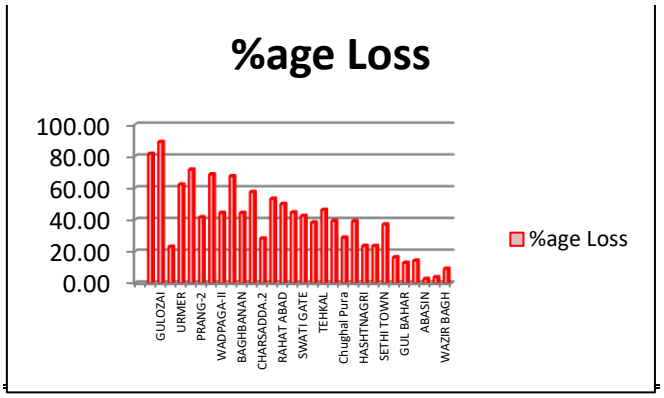

Figure3: %age Losses

The load shedding is being carried out according to the CEI worked out on the basis of %age losses of the feeder as shown in figure 3 and recovery shown in figure 4.

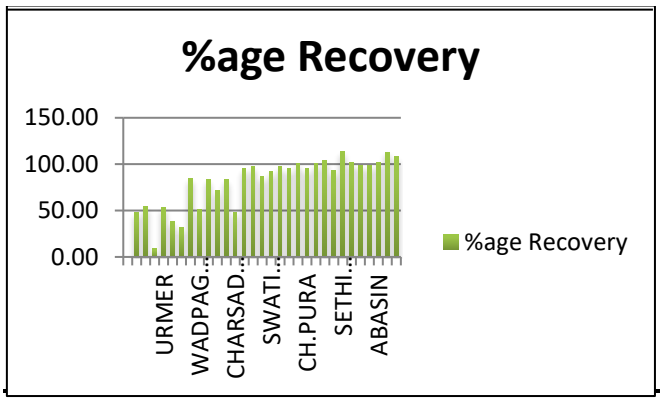

Figure4: %age Recovery

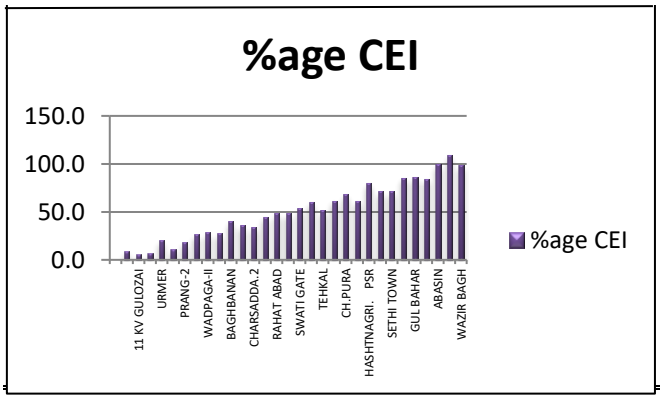

Figure5: %age CEI

The figure 5 illustrates the %age CEI of the feeders, and the load shedding is planned and implemented according to the category in which the CEI lies as shown in Table 1.

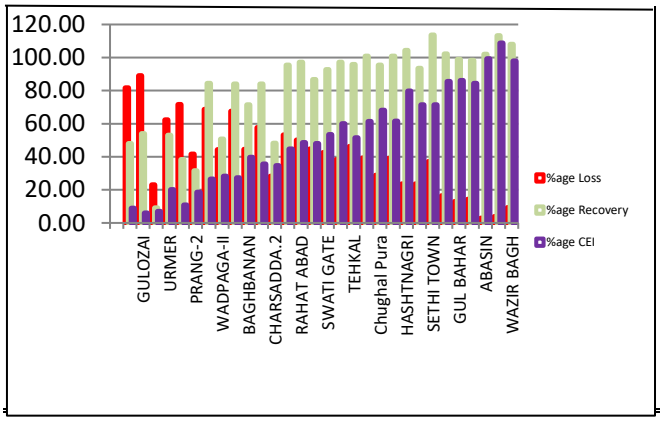

Figure6: %age Loss, Recovery & CEI

The figure 8 illustrates the feeder's %age loss, %age recovery and their CEI. The feeders having poor CEI are subject to more number of power outages (planned) as compare to others having good CEI on which less number of power interruptions are carried out as shown in table 1.

Name of Feeder	**ChagharMatti**		
Quarter	**%age Losses**	**%age Recovery**	**C.E.I**
Jul-Sep 2015	84.4	4.7	0.7
Oct-Dec 2015	81.4	5.65	1.05
Jan-Mar 2016	81.6	6.1	1.1
Apr-June 2016	77.7	7.7	1.7
Name of Feeder	**Lala**		
Quarter	**%age Losses**	**%age Recovery**	**C.E.I**
Jul-Sep 2015	53.7	72.5	33.6
Oct-Dec 2015	44.2	82	45.79
Jan-Mar 2016	40.57	84.4	50.2
Apr-June 2016	42.2	89.3	51.6
Name of Feeder	**Mall Road**		
Quarter	**%age Losses**	**%age Recovery**	**C.E.I**
Jul-Sep 2015	41.3	112	65.7
Oct-Dec 2015	35.8	114.6	73.63
Jan-Mar 2016	34.15	112.9	74.3
Apr-June 2016	32.69	109	73.4

Table 2: ChagharMatti, Lala& Mall Road feeder data

CEI is illustrated for four quarters as mentioned in table 2. Planned Load shedding is carried out as per category of CEI referred to table 1.

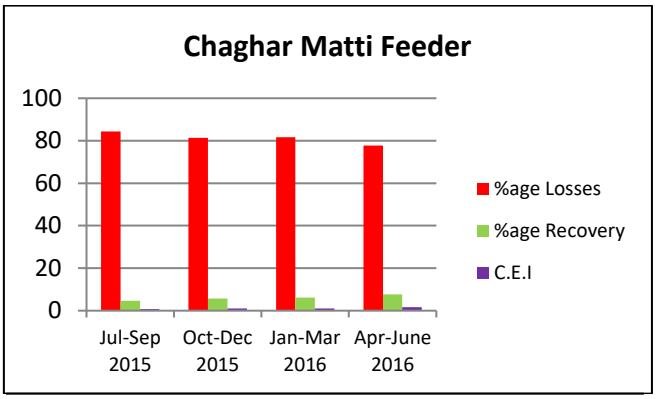

Figure7: ChagharMatti Feeder

As reveal from the figure 7 the maximum %age line losses incurred on the feeder also the %age recovery very poor, resultantly the CEI worked out ranged in 0.7 to 1.7, therefore maximum number (20 Hrs) of planned power interruption is carried out on the feeder referred to table 1.

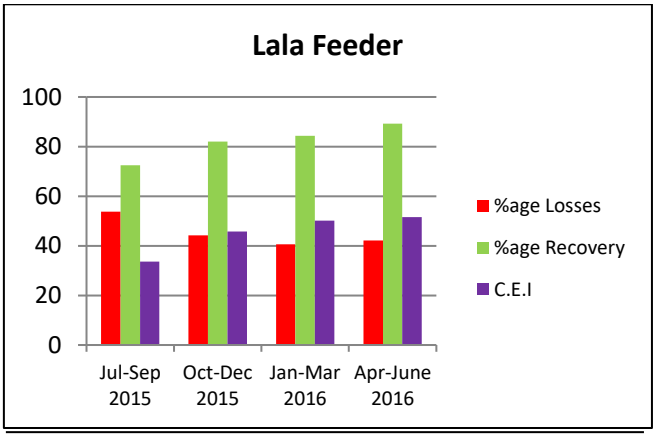

Figure8: Lala Feeder

The CEI of the feeder ranged 33.6 to 51.6 as shown in figure 8, displays gradual improvement and therefore the planned load shedding is carried out according to the CEI as per table 1.

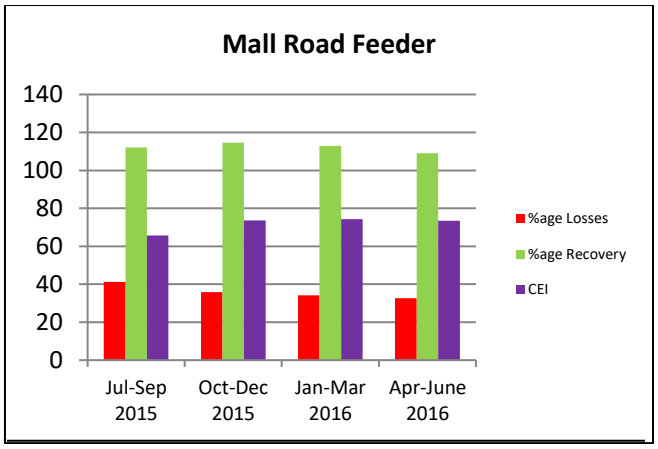

Figure9: Mall Road Feeder

The mall road feeder comparatively low %age line losses and having %age recovery is very good as shown in fig 9, the overall CEI ranged 65.7 to 73.2 therefore minimum (only 04 hrs) as per table 1.

VII. CONCLUSION

In this paper, we have tried to address the issue of electrical power shortage issues in Pakistan in a different aspect. Although the government is trying to address this issue on its own level by constructing more dams and utilizes other sources of energy but the power shortage may prolong for further few years. Hence, we have presented a load management formula and AMR technique with the help of which we can improve the shortfall up to some extent. We considered 3 feeders in our research work and considered the analysis by the use of our technique. We observed significant improvement in the losses as well as financial recovery for WAPDA. The methodology proposed is restricted to KPK province but can be successfully applied to any feeder across the country.

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