SUGGESTIONS FOR IMPROVEMENT OF WAPDA DISTRIBUTION SYSTEM

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INTRODUCTION

Looking at WAPDA statistics give in Annex-I, we can be very proud of development made over the past four decades particularly while comparing with the other departments like Railway, Highways, Irrigation etc. who have very little at their credit. We have spread our network all over the country from 500 kV to consumer voltage. However our operational performance needs a lot of improvement. The trippings are far excessive and can not be compared with any National or International standards. This not only puts consumers to inconvenience but also tars image of WAPDA. In addition excessive trippings shorten life of equipment, resulting in frequent failures and financial burden on WAPDA. The question arises why WAPDA has failed to achieve the required performance standards?

We have to analyse whether fault lies in prescribing the standards, their implementation, the management or the resources. In this lecture, I have tried to give you overall picture of International and WAPDA practices, their comparison and suggestions for improvement through some innovative approach.

COMPARISON OF DISTRIBUTIONSUPPLY SYSTEMS

DEVELOPED COUNTRIES	WAPDA
System is fully planned for the present and the future	There is no planning. System is expanded haphazardly to meet with specific load requirements
Rates high in economic order	Rates lowest in economic order rather ignored. More importance is given to higher voltages
All town areas with population more than 100,000 are mostly fed through primary and secondary Network system with multiple source of supplies and automatic switching operations	99% System is radial with no alternate source of supply
Spare transformation capacity at each substation with automatic switching arrangements	No spare transformation capacity is available.

DEVELOPED COUNTRIES	WAPDA
In case of fully loaded transformers, or radial system standby generators are used	WAPDA cannot afford standby generators
Automatic circuit reclosers voltage regulators, sectionalisers switching capacitors are all integral part of Distribution System to improve stability and continuity of power supply.	WAPDA tried earlier to introduce these equipment in the system but failed to maintain
All important commercial centres and down town areas are mostly fed through underground system for more reliability	Overhead radial system largely dependent upon its freedom from outages caused by Wind, Storms, Lightning, Tree Branches, Road Vehicles and Kites
Materials and workmanship of construction is in accordance with National or International Standards.	Standards are not followed. Extremely poor workmanship results in frequent failure of supply
Routine maintenance is carried according to laid down schedules and all deteriorated, defective or parts having consumed their specified life are replaced.	No routine schedules are followed. Spare parts are normally not procured for maintenance.
All sections of secondaries are fully protected	There is no protection on secondaries. WAPDA works on self clearing principles

WAPDA PRACTICES

There is no doubt that performance of any utility is measured from the quality of service it provides to its consumers. Evidently our proficiency cannot be compared with any developed nations due to lack of financial resources. However in WAPDA system there is a lot of margin for improvement due to lack of proper planning and maintenance and poor workmanship. Let us have a look at some photographs of a posh area in Lahore, which represents our system.

Tilted angle Pole

Poles out of alignment

Rora Fuse

Extra Length of live cable retained and lying along heavy traffic road

i) Inserting of wooden sticks to maintain clearances

ii) Crossing of one L.T. Line over the other by inserting insulators in middle of the span

Jumpering interconnection of 11kV line from Main to Sub-main

Jumble of wires on top of structures

Meter hanging with support of cotton cord

Meter protected with bricks against bird nest

Meter without box & terminal cover

FAULT ANALYSIS

In view of limited financial resources available it is imperative to analyze the causes of interruption in the system and fix priorities. The least cost solutions with maximum impact on improvement in system efficiency should be handled first. For this purpose I carried out analysis of distribution system by collecting data of interruptions from few sub-divisions in Lahore some years back, the results of which are given hereunder. It may be noted that 70% of the system interruptions lie under the category of "Low Tech Faults' and mostly constitute visible faults on line VIZ loose jumpers/connectors, improper conductor clearances, excessive sage due to large spans, which can be resolved within available financial resources. High and Medium tech faults constitute 20% of the total and are difficult and expensive to work with. These faults should be dealt later, once the low tech faults have been fully attended.

Type	Causes	Percentage
HI TECH Faults (Difficult to Identify)	1) Switching Surges 2) Lightning discharge 3) Power frequency synchronisation problems 4) Harmonies 5) Corona 6) Capacitances & inductance of Transmission Line 7) Air pollution	5%
Medium TECH (Simpler to identify)	1) Equipment failures/maloprations 2) Relay malfunctions 3) Indiscriminate trappings 4) Lack of proper protection 5) Insulation Co-ordination	15%
Low Tech Faults (Common Fault, Most of them Apparent & Visible)	1) Non compliance to standards a) Construction b) Materials - Loose Jumpers & Connections - Improper conductor clearances - Loose binding of conductor with insulators - No or Poor earthing - Improper line sag - Unequal or excessive tension on conductors (poles out of alignment) - Broken or cracked insulators - Improper protection to equipment - Imbalance of three phase loads	70%
Low TECH Faults (Beyond Control)	1) External interferences 2) Lightening, Wind storm, Kites, Traffic Accidents Bridge	10%

MEASUREMENT OF PERFORMANCE OF ELECTRIC POWER UTILITIES

Electric power quality problems are a nuisance for both utility and facility. Power system disturbances result in revenue loss to utility and costly down time in industry. WAPDA quality of service cannot be compared with any national and international standard and needs improvement. Voltage surges, sags, swells are common feature in our system which damages costly equipment. In the first stage WAPDA should introduce maintenance statistics sub-division wise in terms of its outages based indices as under, only then comparison with other utilities will be possible.

System average interruption duration index (SAIDI) = $\dfrac{\sum(\text{No consumers affected})\ (\text{Duration of outage})}{\text{Total number of Consumers}}$

System average interruption frequency index (SAIFI) = $\dfrac{(\text{No of consumers interrupted})(\text{No of interruptions})}{\text{Total number of consumers}}$

Customer average interruption duration index (SAIDI) = $\dfrac{\sum(\text{Customer interrupted (No of interruptions)}}{\text{Total number of customer interrupted}}$

Customer average interruption frequency index (CAIFI) = $\dfrac{\text{Total number of consumer interruptions}}{\text{No of customer affected}}$

Average interruption index/km length of feeder = $\dfrac{\sum(\text{No of outage})\ (\text{Duration of outages in second})}{\text{Total number of Consumers}}$

DISCO's as utilities not only calculate above indices but should also prepare for self assessment regarding quality of services to its consumers. In second stage DISCO's should consider introduction of performance monitoring through systematic models and its associated strategies by taking into account the realistic performance related system and consumer concerns to provide safe reliable and cost effective services. World Bank Technical Report entitled "Proposal of Monitoring the Performance of Electric Utilities may be taken as guide.

THE CHALLENGE FOR INNOVATION

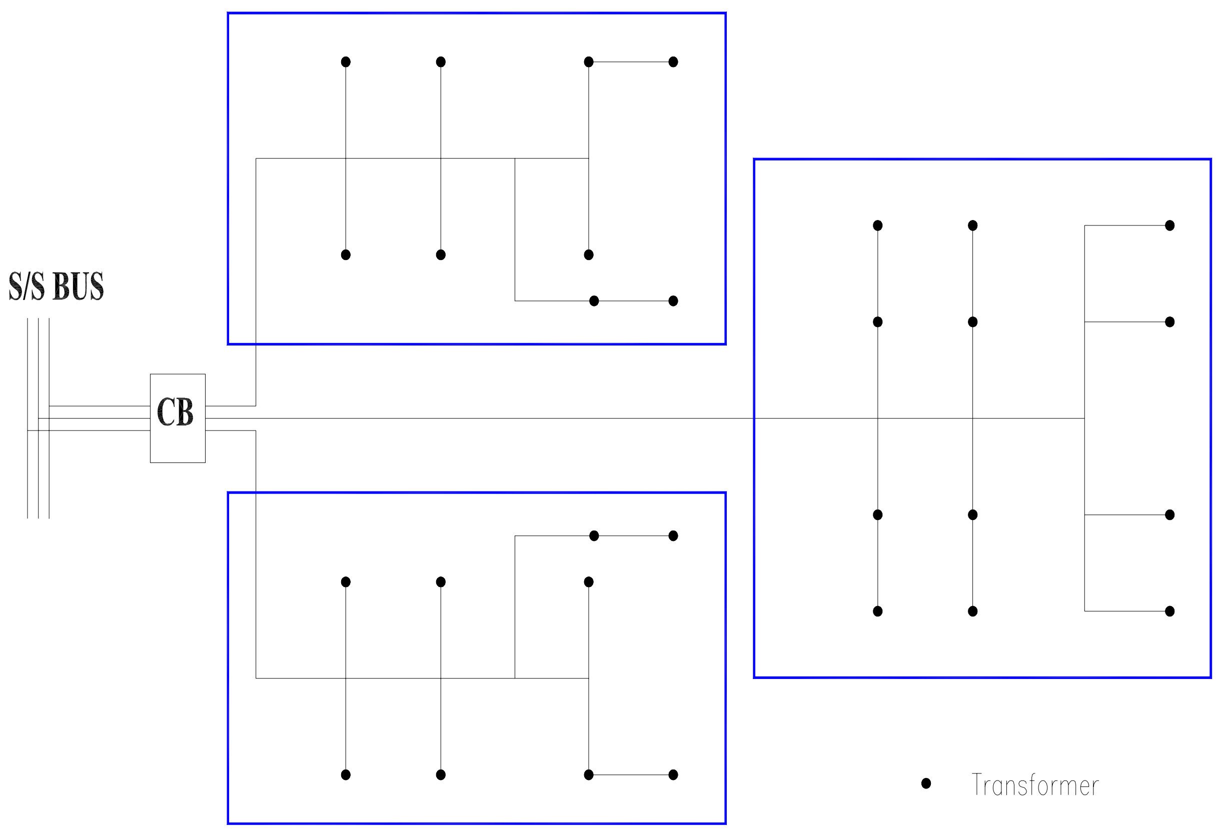
Continuity and stability of power supply is a great challenge for Power Engineers particularly in the tight economic situation as being faced today. With new inventions of material component and computerised controlled operation there are innumerable design options available which offers good ground for continuous dedicated efforts by our engineers. There could be many possible choices of design for distribution of power. The complexity of engineering and economics leaves much room for improvement.

SYSTEM IMPROVEMENTS FOR EXPANSION

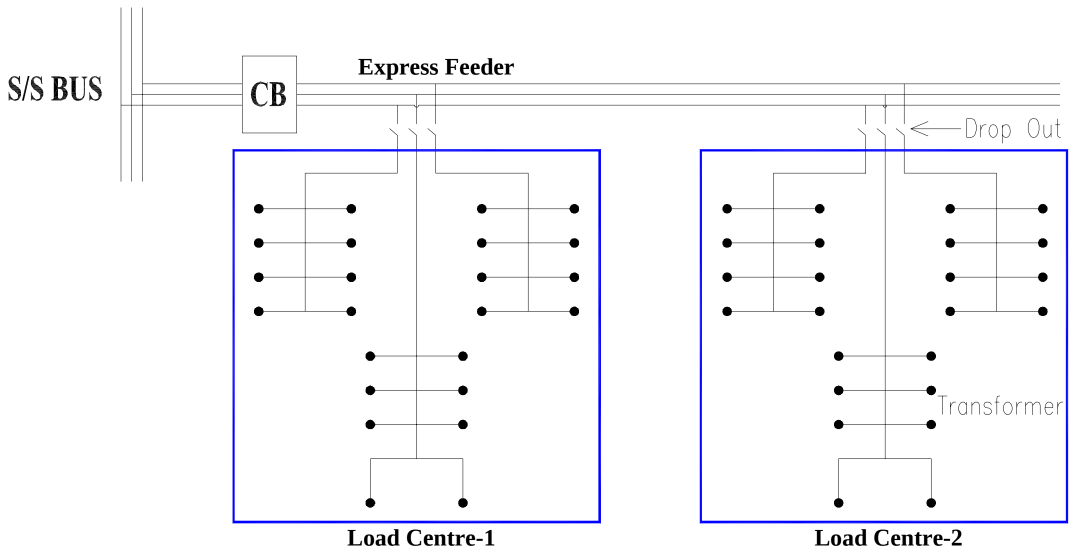
Single Phase System

The simplest Form of single-phase system is the supply to consumers through radial feeders which depending upon geographical position of the load center with respect to the location of the grid station. Here are few examples to illustrate single-phase distribution system.

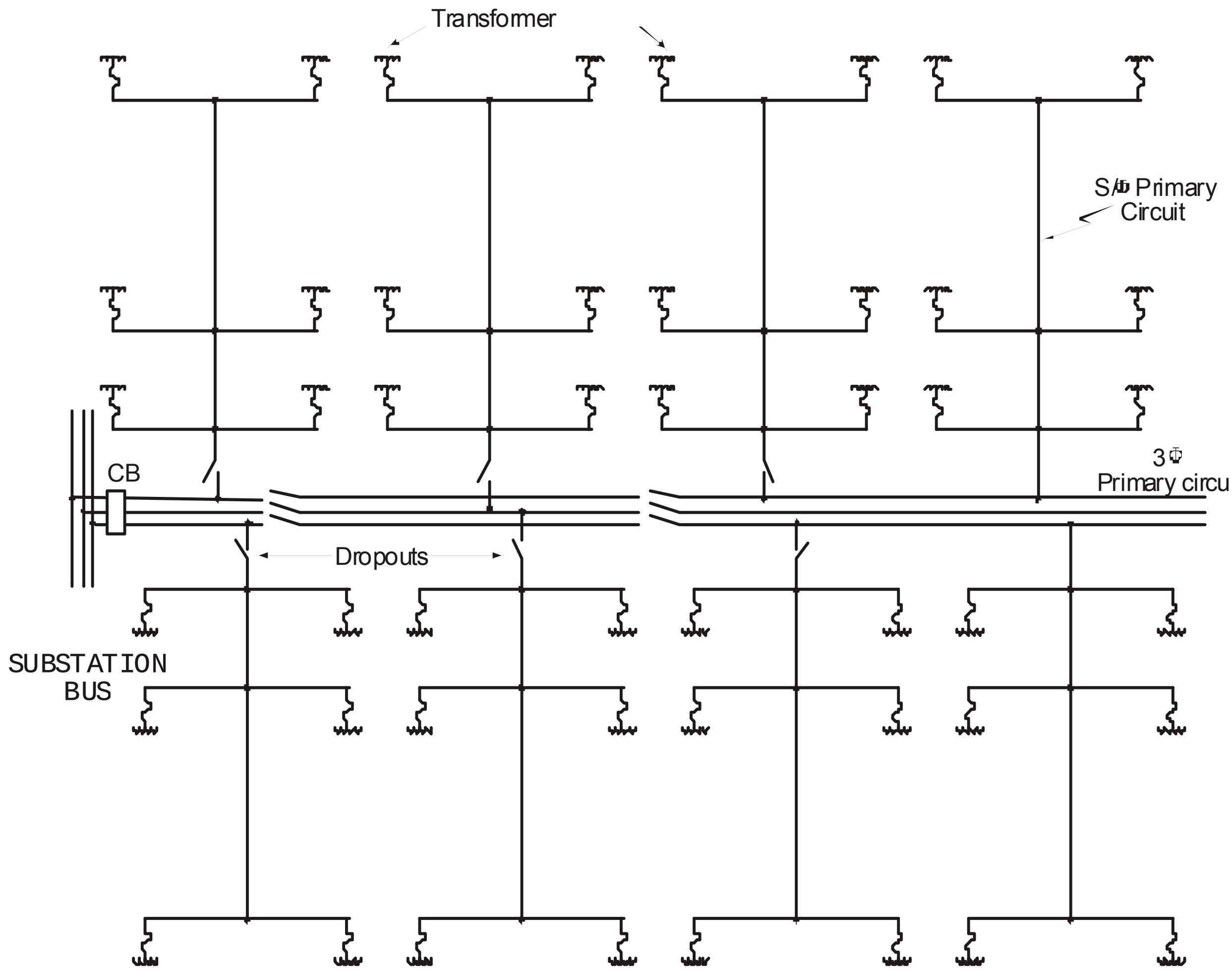
a) When load center is located within the grid station, each individual phase goes directly to its area right from the sub-station and each phase feeds a defined area as shown in Figure. Such system is not very popular as future expansions of the system could create a problem of load balance.



b) When load centers are located at a distance from the sub-station 11 kV, 3 phase express feeder is laid to the load centers and no load is distributes over this portion. The typical example of this is the villages located in small clusters over the area. The express feeder is so designed that it passes close to the load centers. Single phase feeders are taken out near the load centers from the three phase express feeders and then bifurcated into single phase feeder in three different directions which feeds the consumers as shown in Figure.



c) A more extensive radial 11 kV circuit is shown in Figure. Three phases 11 kV circuit passes through the load center where it can feed three phase supplies to commercial and industrial areas. Single-phase feeders are taken from three-phase main line to feed residential areas. Such a radial feeder is more commonly used in low-density urban areas.



COST COMPARISON OF THREE PHASE AND SINGLE PHASE SYSTEM

The cost comparison of single and three phase system assuming I KM length of HV feeder with 2 Nos. transformer of 100 KVA each and 1 KM length of LT feeder is as under:

Cost of Three Phase System

	Qty	Unit rate	Cost
3 phase 11kV line with P.C. poles & Dog Conductor	1KM	408,000	1408,000
100KVA (11/0.4kV) complete S/S	2 Nos.	185,000	370,000
3 Phase Service connection with 7/0.36, 4 core cable	30 Nos.	9400	282,000
LT line with Ant conductor	1KM	225,000	225,000
TOTAL COST			1,285,000

Cost of Single Phase System

Single phase 6.3kV line with P.C. poles & dog conductor (No cross arms, No supports only one conductor)	1KM	272,000	272,000
Single phase 100KVA transformer (6.3/0.24kV) transformer S/S complete	2 Nos.	140,000	280,000
LT line with two wasp conductors	1KM	200,000	200,000
Services 3 phase with 7/064 conductors	30 Nos.	4500	135,000
TOTAL COST			887,000

Cost of single phase system is at least 33% cheaper compared with three single phase system. We can have still more savings up to 40% of total cost by designing lighter poles for single conductor. In addition single phase system will drastically reduce cost of maintenance and improve power supply as there will be no problem of phase to phase short circuits.

ADVANTAGE OF SINGLE-PHASE SYSTEM OVER THREE-PHASE SYSTEM

The advantages of single-phase system over three-phase system are elaborated below:

i. Single-phase system is 30% to 40% cheaper compared to three-phase system.

ii. It is simpler and easier to maintain as Single-phase will carry only one conductor for 11 kV and two conductors for LT feeders.

iii. 11 kV single-phase system can be laid down in narrow streets as cross-arms are eliminated.

iv. 30% larger span can be used with the same height of structures.

v. There will be no phase to phase short circuits due to improper sags, unequal or loose tension on conductor, broken or tilted cross-arms.

vi. Over hanging branches of trees will not cause any short circuit as in case of three-phase system.

vii. There will be no short circuits on 11 kV feeders due to kite strings.

viii. There will be no problem due to imbalance of loads on single-phase transformers as in case of three-phase system.

ix. Three-phase transformers are more vulnerable to short circuits compared to single-phase transformer.

x. Damage to grid station equipment will be reduced proportionate to reduction in faults on 11 kV system.

xi. Balancing of load on 11 kV feeders will be easy.

INNOVATIVE TIPS

LOOSE SPANS

In city areas construction of 11kV composite line with large span is common practice and results in loose spans for LT line underneath it. To support loose spans either L.T. Structure is inserted in between or wooden sticks are used to keep clearances. This non-standard practice should be standardized by inserting properly designed spacers made of insulting material with fixing arrangement. This will save a cost of construction as well as reduce interruptions.

DROPOUT CUT OUTS

I. PROBLEM

Almost 90% of transformers are fitted with rora fuses. It is almost impossible to replace fuse rods at site due to interchangeability problems of rods supplied by different manufactures.

SOLUTION

Few hundred dropout cutouts complete with fuse holder be procured and defective ones replaced at site. Defective dropouts should be brought to a local workshop repaired and fitted with new fuse holders and then cycle repeated in other areas.

II. PROBLEM

It is common practice to replace standard fuse links in cutouts with a solid wire, which cannot protect transformer against overloading and short-circuits.

SOLUTION

It's a management problem; standard fuse links are not available in the complaints centers. XEN should be allowed to procure this item in bulk and SDO's should ensure their availability in the complaint centers.

BURNING OF TRANSFORMERS

I. PROBLEM

INGRESS OF MOISTURE SOLUTION

Transformer design needs to be reviewed. Moisture enters through poor gaskets due to breathing action of the transformers. To seal entrance of moisture, use of round gaskets is recommended instead of flat ones. Preferably totally welded design will be a better solution as is being practiced in USA.

II. PROBLEM

Loose connector joints on transformer bushings results in heating and burning of jumpers and inside winding connections.

SOLUTION

This can be avoided by designing bigger connectors with crimped joints facility or bolted plate connections for connecting to conductor.

III. PROBLEM

Unbalance loadings on three phases results in overheating of windings and transformer break down.

SOLUTION

Balance loads or introduce single phase transformers

EXCESSIVE INTERRUPTIONS

I. PROBLEM

Loose wrapped a connector joints on tap, mid span or jumper positions

SOLUTION

Introduce crimped joints replacing connectors and wrapped joints an all ht & lt distributions lines

II. PROBLEM

Bad Workmanship

SOLUTION

- Change existing construction and monitoring system.
- Reduce dependence on departmental employees.
- Work through contractors and consultants, can improve situation.
- Follow standards

SYSTEM EXPANSION & USE OF EXISTING THREE PHASE SYSTEM AS SINGLE PHASE

I) WAPDA must consider to introduce single phase distribution system for supply to domestic and small commercial consumers in all rural and urban areas. It will not only reduce 30% to 40% of investment and maintenance costs but will also drastically reduce interruptions, prolonging life of distribution transformers and equipment installed at grid stations.

II) All three phase small transformers on damage may be replaced with single phase units thus substituting three phase with single phase system, where applicable. we can replace the existing three phase system to single phase in stages. I may add that existing three phase lt distribution network can be very effectively used on single phase system without any change.

WE ALL KNOW THIS

These are common problems and well known to all of us. Then why cannot we improve our system as sufficient manpower and financial resources are also available to boost WAPDA image. I am sure we can reduce outages on our distribution system by 70% within the available resources. In my humble opinion there seems to be lack of will to do things. Our nation needs motivation in form of recognition for good work, incentives, awards etc which I am, sure can be achieved with little cost.

LET US DO SOMETHING

Few will have the greatness to bend history itself, but each of us can work to change a small portion of events, it is from these number of acts of courage and change of events that human history is shaped.

ROBERT F. KENNEDY

Hold fast to dreams for if dream dies Life is a broken winged bird that cannot fly. Hold fast to dreams for when dream go Life is a barren field frozen with snow.

LINGSTON

Annex-I

WAPDA STATISTICS AS IT STANDS UPTO YEAR 2000

Total number of consumers	14 million
Total length of 11 kV lines	202,000 KM
Total length of LT lines	138,000 KM
Total number of distribution transformers	300,000 Nos.
Total capacity of transformers	22,000 MVA
Total number of distribution transformers damaged every years	6000 Nos. approx.
Total distribution Transformer capacity lost every year	600 MVA approx.
No of trippings below 20 min/year	500,000 approx.
No. of trippings above 20 min/year	60,000 approx.
Momentary Trippings	Not recorded
ECONOMIC INDICATOR	
Per Capita Energy Consumption	300 KWH per annum which $1/80^{th}$ of world average
Per Capita income in Pakistan	US$ 450 Compared to 30,000 US$ of USA