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Energy loss reduction in Wapda power distribution system

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ENERGY LOSS REDUCTION IN WAPDA POWER DISTRIBUTION SYSTEM

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1. INTRODUCTION

One of the most chronic problems facing WAPDA is the excesive loss of energy in its power system. There was little realisation to improve the situation until the impact of the sudden increase of oil prices was felt nearly ten years ago. The country-wide scarcity of energy resources and the increasing costs of energy supply highlighted both the importance of energy conservation as well as reduction in the Power System losses.

Average sale price per unit (KWH) of electricity was only 11.51 p in 1959–60 which had remained static even at current prices until 1972-73 when it had barely risen to 13.95 p. Then there was a sudden impact of oil crisis and the average sale price/KWH rose to 75.6 p by 1985–86. There was little urgency to pay any serious attention to mundane system power losses when the electricity sale price was virtually stable for 12 years. WAPDA pursued its generation and transmission projects vigorously which resulted in quantum jumps in power supply. Since power supply was mainly hydro-electric from Tarbela and Mangla, the repercussions of the oil price increases in 1973 and 1979 were slow to perceive. When the effect of energy price increases resulted in increased power-tariffs, the system losses increased tremendously and touched an all time peak of 37.58% in 1976–77.

By this time, international lending agencies exerted pressure for reduction of these losses. The net generation in WAPDA is presently 20.6 Billion Kwhr (1985–86). If a reduction of 5% in Transmission and Distribution could be achieved, the annual saving would be Rs. 780 million at an average sale price of 75.6 p/KWH. Since the power tariffs are increasing continuously the amount of saving would also be substantially higher in the future years.

In the process of delivering electricity to the consumers, losses are incurred in generation, transmission and distribution of the electric power. The manufacturers of power generating equipment are increasing the efficiency of their plants, particularly of thermal units. Presently 2.15% of generation is lost in auxiliaries at the Power Stations in Pakista. These losses are considered within acceptable limits. Transmission losses at 9.3% are rather high and steps are being taken to reduce these losses by bulk transmission at higher voltages, installation of capacitors and optimisation of transmission routes. The length of transmission lines is rather long in Pakistan, with the bulk of hydro-electric generation concentrated in the North and thermal power plants located in mid and southern portion of the country. It is technically possible to reduce the transmission line losses by a further 4% although aconomic level for losses in transmission system are even lower.

This case study will examine the energy losses in the Power Distribution System which are currently 15.3% and are made up of both technical and non-technical losses. The causes of these losses will be examined and various steps taken to achieve reduction, particularly in non-technical losses, which are also termed as administrative losses. These non-technical losses are essentially on account of theft of electricity.

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2. GROWTH OF POWER SYSTEM IN PAKISTAN

Before the system losses could be studied in a proper perspective, the historical growth of power supply in Pakistan makes an interesting background reading.

Inspite of phenomenal increase in the power generation facilities the power supply position has remained precarious since the time of independence in 1947, except for brief periods of respite when Warsak, Multan, Mangla, Guddu and Tarbela were commissioned. The total installed capacity in 1947 was barely 37 MW. Lahore, Kasur and Lyallpur were supplied from Mandi Hydro-electric Scheme located in India. India continued to supply power to the Punjab until 1954 and we, in turn, maintained supplies to Ferozepur. The authorities were acutely aware of the delicate situation and new Power Stations were planned immediately. With the commissioning of Rasul Power Station of 22 MW in 1952 and subsequent establishment of a small grid network linking Rasul with Lahore, Lyallpur and Sialkot, there was a considerable sense of relief and imports from India were reduced to a minimum and then completely abandoned in 1954.

In NWFP, Jabban Hydro-Electric Station was extended by 10 MW and Dargai Power Station of 20 MW commissioned. NWFP was in an enviable position with regard to power supplies and embarked on Rural Electrification in early fifties when it was considered an absolute luxury.

The concept of an integrated grid network developed very quickly in line with the modern engineering practice. Jabban-Dargai System was paralleled with Rasul in 1956. At the time of creation of WAPDA, the total generating capacity had risen to 119 MW of which 52 MW was Hydel and 67 MW Thermal. When Power Stations at Warsak (160 MW) and Multan first stage (130 MW) were commissioned in 1960, this only provided a temporary relief.

With the construction of Mangla Hydro-Electric Power Station having an ultimate capacity of 800 MW, extension of Multan Power Station by two machines of 65 MW each, consturction of a new Power Station at Lyallpur (130 MW) and 220 KV Double Circuit Lines between Mangla, Lahore, Lyallpur and Multan, WAPDA had made giant strides towards providing a sound power system.

Inspite of these quantum jumps in generation, the power demand quickly rose to meet the available generation. Experience has shown, that in an unsaturated power system like Pakistan, if adequate generating capacity is available and there are no transmission or transformation bottlenecks, the demand rises rapidly and in a short time matches the generating capacity.

It may be stated, that as a general rule, power acts as a leader of the industry. There is a definite relationship between growth rate of power consumption and GNP growth rate. This elasticity factor is nearly 1.5 in developing countries in case of unsaturated power demand.

Quantum jumps in power generation and demand have continued without any respite. Present installed capacity of WAPDA system is 4,985 MW, of which 2,897 MW (58%) is hydel and 2092 MW (42%) thermal. Major Hydel Power Stations are: Tarbela present capacity 1750 MW Mangla 800 MW, Warsak 240 MW. Major Thermal Power Station are: Multan Steam 260 MW, Faisalabad Gas Turbine 200 MW, Guddu Steam 640 MW, Guddu Combined Cycle 440 MW, Faisalabad Gas Turbines 200 MW and Kotri Gas Turbines 130 MW.

During the period 1959 to 1984, installed capacity increased at an annual compound growth rate of 15.7%

Mamimum Demand which was 131 MW in 1959-60 had risen to 3791 MW in 1984-85, an annual increase of 14.4%. The electricity generation rose form 781 GWH to 18,777 GWH during the same period, depicting an annual growth rate of 13.56%

The Transmission System has developed as follows:

Voltage	Length in K.M's as on 4/59	Length in K.M's as on 30.6.1985
500 KV	–	1287
220 KV	–	1432
132 KV	854	9239
66 KV	2147	7389
Total:	3,001	19,347

On 30.6.1985, there were 457 Grid Stations in operation with a total installed capacity of about 14,493 MVA.

Generation and Transmission Schemes of WAPDA have been well planned and executed. Funds have been contributed to all the major Power Stations and Transmission Systems by the International lending agencies or provided under bilateral agreements. Reputable Consulting firms have supervised and engineered these projects. Performance of WAPDA in these fields has been lauded. But it is a different story in Distribution, where until recently, no foreign assistance was received. Since Distribution is at the tail end of the Power System, it was invariably subject to drastic ADP cuts. Distribution has for long been the neglected sector, it has no "glamour" attached to it. All the weaknesses of the entire power system are manifested in Distribution. As a consultant called it, "this is where the rubber meets the road".

But distribution has grown, even though haphazardly, in the same quantum jumps that are evident in power generation.

In 1947, the number of consumers was 59,000. At the time of creation of WAPDA, the number of consumers was 278,000 which has risen to 4,840,786 by 30.6.1986. An additional 320.506 consumers were added in 1985-86. WAPDA crews have to maintain 105,000 KM of 33/11 KV lines, 60,000 KM of L.T. lines and a total number of 135,000 pole mounted substations with a capacity of app: 7,500 MVA. Distribution Wing alone employs more than 80,000 persons, accounting for more than half the total employees of WAPDA.

3. PATTERN OF CONSUMPTION OF ELECTRICITY

The system losses are directly affected by the pattern of electricity consumption. In highly industrialised societies, the losses would be low because bulk of power is transmitted over short distances from the Grid Stations to the sites of major industries. In widely dispersed distribution facilities, where large number of residential consumers are to be supplied power, the losses would increase and the possibility of theft of electricity is also higher. The problem is furthercomopundedby tubewell and village electrification where the technical losses are high due to length of lines and pilferage of electricity is more difficult to control.

Consumption of electricity in 1947 was 51 GWH which increased to 537 GWH by 1958-59. This rose to 15504 GWH during 1985-86.

There has been a substantial shift in the pattern of electricity consumption since the formation of WAPDA. In 1959-60, Industrial, Agricultural and Domestic/Commercial consumers accounted for 65%, 11% and 16% of the total consumption. But during 1985-86, Industrial, Agricultural, Domestic/Commercial consumers used 37%, 19% and 34% of total energy respectively. The balance of the consumption was on account of Public Lighting, Bulk Purchase and Traction.

This clearly highlights the trend of the society towards consumption. Domestic/Commercial sector now accounts for 34% of total sale of energy, which has more than doubled since 1959-60. Industrial consumption has, on the other hand, not increased correspondingly, and its share has been reduced from 65% to 37%. It is interesting to note that the industrial energy consumption remained virtually static from 1971-72 to 1976-77.

Categorywise consumption of electricity for typical years is given below in the table:—

CATEGORY—WISE CONSUMPTION

Year	Domestic	Commercial	Industrial	Agricultural	Public Lighting & Traction	Bulk Supply	Total
1959-60	81	18	390	67	5	42	603
1966-67	232	72	1095	389	12	297	2097
1971-72	392	142	2109	997	19	478	4137
1976-77	780	246	2295	1400	29	702	5452
1980-81	1858	445	3482	2125	58	1100	9068
1983-84	3470	739	4708	2663	75	1107	12762
1985-86	3888	796	5061	2782	77	1152	13756

Tubewell consumption has increased from 11% to 19% during the last 25 years. This has been a major factor in the increase in losses. WAPDA tariffs to the tubewells are lower than the average cost per unit sold. Accordingly, there is a built-in subsidy. Tubewell owners are even then reluctant to pay their dues, particularly in interior Sind and Baluchistan.

Overall consumption of electricity has shown an annual compound growth rate of 13.56%.

4. EFFECT OF ELECTRICITY TARIFFS

Electricity tariffs do not contribute to technical losses. But these tariffs cause distortions in economic patterns and social life-style of industrial, agricultural and domestic consumers. Pricing will cause shifts in non-technical losses, mainly theft of electricity. Major industrial consumers cannot escape payment of electricity bills due to stringent checks, and multiple metering arrangements. Medium and small industries evolve most ingenious methods for the theft of electricity which in most cases involves WAPDA staff, and the methods used are according to tariff structure applicable in a particular case. In case of domestic onsumers, technical losses are high due to poor workmanship. But tariffs, particularly "slab" tariffs,

encourage the prosperious consumers using many air-conditioners to indulge in mal-practices, either with or without the connivance of WAPDA staff.

WAPDA Act, 1958 requires that the rates at which WAPDA shall sell power, "be so fixed as would provide for meeting the operting costs, interest charges and depreciation of assets, the redemption at due time of loans other than those covered by depreciation, the payment of any taxes and a reasonable return on investment". But the final authority in the matter of fixation of rates is the Federal Government.

Uniform tariffs were introduced throughout WAPDA area in July 1969. From July 1971 to November 1981, WAPDA tariffs have been increased on 11 occasions. Overall average sale rate which was 12.46 p/KWH in 1970-71 has increased to 53.17 paisas/KWH in 1983-84, and 75.6p by 1985-86.

In order to avoid increase in tariffs whenever prices of fuels were increased, a Fuel Surcharge Clause was added in WAPDA tariffs from July 1978. This is not applicable on domestic consumers. This surcharge is averaged out over a period of previous 12 months on account of fuel consumed by WAPDA. Fuel Surcharge in WAPDA system average between 12 p to 26 p/KWH since their system is entirely thermal. No formula for equalisation of fuel surcharge has yet been devised due to regional interests.

The effects of power tariffs as presently applicable on different categories of consumers are as follows:–

DOMESTIC

The present domestic tariff effective from 1 July, 1985 is in slabs and increases with the i increases with the increased consumption of electricity as follows:

First 50	KWH	37 p/KWH
51–250	KWH	44 p/KWH
251–600	KWH	55 p/KWH
Above 600	KWH	77 p/KWH

The basic idea is to conserve electricity and avoid wasteful use. But the effects appear to be marginal in a consumption-oriented society like Pakistan. There are 3.8 million domestic consumers, of which more than 90% consume less than 600 KWH/month, who pay less than the cost per KWH to WAPDA. In this vast category of consumers, the technical losses are high and the theft is widespread either in Katchi Abadis. Slums and the congested streets or high-income districts like Gulberg and Garden Town. The consumers in tribal areas, Afghan refugee camps and Baluchistan simply do not believe in paying any dues to the Government.

Sliding tariff rates have a direct impact in case of consumers using air-conditioners and other electrical appliances. People do not mind paying Rs. 10,000 for the installation of an air-conditioner but they are reluctant to pay similar amount every year on account of electricity consumed. It is this category of consumers who indulge in wide-spread theft, with or without the connivance of WAPDA staff. The highest feeder losses are in Gulberg and Garden Town in Lahore where mostly businessmen live, majority of which who have little moral compunction even if they are caught. Losses in G.O.R. estate and even Cantonment are comparatively lower. This may be an indicator of social values.

Only ten years ago, tariffs used to be lower on increased consumption to encourage greater usage of electricity. Oil crisis has suddenly diverted the attention of planners to greater conservation and higher pricing is used as a tool.

A brief description of development of tariffs may be useful. At the time of independence, isolated electric power companies sold electricity at rates varying from 50 p—Rs. 3 per unit. After the commissioning of the Grid System in 1954, the tariffs were rationalised and soon brought down to 25 p/KWH. Further reductions took place until 1972. The present average sale price to domestic consumers is 45.22 p/KWH. This is probably the only commodity where prices were reduced dramatically as a result of centralised generation, which was more economical, and icnreased efficiency of power plant and transmission lines.

COMMERCIAL

This tariff is applicable to shops, hotels, restaurants and other commercial establishments as follows:— (effective 1 July 1985).

First 100 KWH	Rs. 1.10/KWH
Balance	Rs. 1.22/KWH

This is a flat-rate tariff and applies to 0.78 million consumers. Due to the high tariff compared to Domestic consumers, there is considerable temptation to steal, particularly by the prestigious private hospitals and clinics, and restaurants, who are reluctant to pay the proper dues which might cause incidence of high income-tax also.

INDUSTRIAL

There are 135,100 industrial consumers compared to 3.8 million domestic consumers. Due to their large number, the domestic consumers exert a powerful lobby and the Government is reluctant to increase domestic power tariffs, which are lower than the cost of sale in case of more than 90% consumers. The industrial consumers have to bear the burden, and most of the tariff increases relate to industries and commerce. Even though the cost of power supply to industries is lower in Pakistan than many other countries of the world, the industrialists feel the pinch due to differential tariffs and feel justified in evading payment of electricity bills.

The industrial tariff is two-part tariff, consisting of a fixed charge varying from Rs. 61 to Rs. 88/KW of maximum demand (MD) and energy charge of 35 p to 40 p/KWH. In case of industries consuming less than 70 KW, the charge varies from Rs. 24 to Rs. 31/KW of maximum demand and 69.0 paisas/KWH.

The two-part tariff is similar to international practice and places high value on capacity utilization. An industry with 50% utilization capacity would not pay more than average of 60 p/KWH. However, due to unplanned operation of the factories, some industries pay anywhere between 70 p/KWH to 90 p/KWH. Overall average sale price to industry during 1985-86 was 69.0 p/KWH.

Accordingly, in a two-part tariff, there is little incentive to steal energy or KWH (although some industries do) but to depress MDI or maximum-demand in KW by unfair means. Maximum tempering is done with MDI meters and highly ingenious methods are used in order to circumvent time-mechanism of recording, which is even more complicated than safe-breaking. The effect of energy and revenue losses is most visible in two part tariffs.

BULK SUPPLY

This is only given to Licencees, Railways, Cantonment Board and other approved institutions. There are hardly any losses in this sector because there are no incentives on either side.

TUBEWELLS

This is a highly subsidised tariff and is as follows:– (effective 1 July 1985)

SCARP Tubewells (Govt.)	44 p/KWH
Tubewells in NWFP and Baluchistan	Rs. 19.00/KW per month plus 18.00 p/KWH.
Punjab and Sind	Rs. 21.00/KW per month plus 25.0 p/KWH

Inspite of the high subsidy, this facility is highly misused and this category of consumers engage in mal-practices. WAPDA did not have any difficulty in billing SCARPS and there were frequent cases of over-charging, since there was little incentive on either side. But SCARP authorities have become wise and are providing meters for installation at their premises.

Other agricultural consumers are mostly feudal lords who are reluctant to pay electricity bills of their tubewells and occasionally use force to coerce WAPDA staff, who are in many cases more than willing to join hands with the landlords.

Extreme case of non-payment is Baluchistan, where the electricity bills have not been paid in many areas for ten years. It is the grace of the customer if he pays anything to WAPDA with the result that arrears are mounting at the rate of Rs. 1.5 crore per month, and the realisation is hardly Rs. 1 crore/month. Distribution losses at 29% are in addition to this assessment. Whenever, the tubewell consumers (particularly of Pishin) are disconnected, the law-enforcing agencies order the reconnection in "the interest of peace".

The tubewell consumers of interior Sind and NWFP are also reluctant to pay the electricity dues and it is a continuous battle, with recriminations against which WAPDA staff have little protection.

5. OTHER CONTRIBUTORY CAUSES

WAPDA system is subjected to low quality equipment used by consumers. In case of tube-wells, the electric motors are made of sub-standard materials by many spurious manufacturers, and since proper laminations, insulation and wiring are not used, the power factor is sometimes as low as 0.4 and hardly ever better than 0.65. Same is the case with electric fans where there is no quality control This causes low power factor and high losses. Air-conditioners also impose high inductive load. Tubewells do not have any motor-starters or protective devices. All these factors cause additional strain on the WAPDA system for which corrective measures have to be adopted at a high cost.

6. SYSTEM ENERGY LOSSES IN WAPDA SYSTEM

At the time of formation of WAPDA, System losses were 22.79% These increased with the increase in Maximum Demand and extension of transmission and distribution system. These system losses touched an all-time peak of 37.58% in 1976/77. The following table gives Maximum Demand and, System losses in some typical years.

Year	Historical Max: Demand usually in June (in MW)		System Energy Losses as % of Gross Energy Generation
1959-60	131		22.79
1966-67	476		30-47
1971-72	1.027		31.38
1976-77	1,620		37.58
1980-81	2,473		31.33
1983-84	3,295		29.3
1984-85	3,791		26.74
1985-86	4,258	(est)	26.6

The division of these losses into power station auxiliaries, transmission and distribution is given in the following table:-

Year	Total Generation (M.KWH)	Auxili-aries % losses	Trans-mission % losses	Units Sold (M.KWH)	%age Distri-bution losses	%age losses on gross generation
1	2	3	4	5	6	7
1976-77	8784	3.0	12.3	4525	22.3	37.6
1977-78	10089	2.2	12.2	6489	21.3	35.7
1978-79	10599	1.9	12.2	6980	20.1	34.1
1979-80	12124	2.2	11.0	8159	19.5	32.7
1980-81	13206	2.6	10.7	9067	18.1	31.3
1981-82	14767	2.6	9.2	10288	18.5	30.3
1982-83	16492	2.5	9.5	11586	17.7	29.7
1983-84	18052	2.2	9.9	12761	17.2	29.3
1984-85	18777	2.1	9.4	13756	15.2	26.7
1985-86	21093	2.1	9.2	15504	15.3	26.6

It will be noticed that 2.2% of generation is lost in Auxiliaries which is within acceptable limits. Transmission losses at 9.3% can be further improved by technical measures.

The distribution losses have been brought down from 22.3% in 1976-77 to 15.3% in 1985-86, but there is considerable scope in further reduction of these losses.

The figures of overall %age losses in WAPDA system are authentic since the total generation at Power Stations is metered and units sold as per actual billing are also available from computer records. The percentage of technical and non-technical losses in the Distribution is a highly controversial subject and will be discussed later.

7. **WORLD BANK COVENANT**

The World Bank has negotiated a loan for the Fourth Power Project to WAPDA. One of the pre-conditions is that WAPDA should reduce its overall System Losses to 23% by June 1988. Excluding Power Station auxiliaries, this target would be 21% by June 1988. The target appears difficult to achieve under the present cirumcumstances. Providing ad-hoc targets for reduction of losses to various field formations is not the answer, as has been realised by the World Bank. Ad-hoc targets result in "strong-arm" tactics by the field formations who achieve the result by bogus and estimated readings and providing wrong returns of billing.

8. **REALISATION OF PROBLEM**

Energy loss reduction is a multi-faceted problem and has received attention recently due to the pre-conditions attached by World Bank and USAID on their loans. As a part of $ 3 billion aid to Pakistan, USAID has agreed to finance a Rural Electrification Programme at a cost of $ 170 million with a similar amount to be provided by the Pakistan Government. Rural Electrification has always been a favourite project to be financed by lending agencies. Asian Development Bank has also financed a similar project in WAPDA where a total of 1,600 villages would be electrified. Physical execution of work in such projects is easy to achieve and the results are visible. However, when USAID commissioned a study, it was realised that taking electricity to another 2,500 villages alone would not be adequate in a system which is overloaded and over-extended. USAID study identified the following four components of the project:–

(i) **INSTITUTIONAL IMPROVEMENT.** The distribution Wing of WAPDA needs a through overhaul of its administrative set-up and institutional improvements are needed to make it an effective organisation.

(ii) **TRAINING.** Adequate training at all levels is utterly inadequate and training both within Pakistan and USA is proposed for Distribution staff.

(iii) ENERGY LOSS REDUCTION. The existing distribution system is overloaded and extensions have been added without any technical designs. There are no maps of existing system and whatever is existing is not reliable. Energy Losses in Distribition System are high and need to be brought down systematically.

(iv) **RURAL ELECTRIFICATION.** An additional 2,500 village are to be electrified in this programme.

USAID have decided to change the name of the project to Power Distribution Project bacause only item (iv) relates purely to Rural Electrification. It has been realised that the entire distribution wing needs to be re-vitalised.

9. **TECHNICAL LOSSES**

Technical losses are caused whenever power is transmitted between two points due to the resistance of the line, transformation of voltage in transformers, isolators, connectors and other electrical equipment. Technical losses can never be r[illegible]:o Zero, because electricity always generators some heat when it flows, thereby causi[illegible]. The amount of heat, and therefore losses, increase exponentially when the current in [illegible]nductor increases. Since these technical losses can not be eliminated, the engineering practice is to tr[illegible]ep these technical losses at a point where their cost is less than the capital cost of a dditio[illegible]nvestment to meet the demand.

The specific objectives of reduction of technical losses whould be to:–

(i) Identify areas within a power system where loss optimisation would be most effective.

(ii) Determine methods for isolating technical losses on a system.

(iii) Develop a framework for economically evaluating alternative means of reducing losses on an existing system and determining the optimal loss levels.

(iv) Develop practical methods for including the effects of losses in establishing the engineering criteria used in design and operations.

Causes of technical losses and measures adopted in WAPDA to reduce the same are given below:–

LONG LENGTH OF FEEDERS

Since the development of distribution has been haphazard, particularly in rural and tubewell electrification, the lines have been extended without any design criteria. As a result, some of the 11 KV feeders are more than 150 KM long. One reason is that the field units are given physical targets, and in order to achieve the same, they have extended the lines without any technical design. Political pressures have also been exerted for extension of the feeders. The lack of alternative points of power supply have contributed to long 11 KV feeders.

WAPDA have a vast network of 500 KV, 220 KV, 132 KV and 66 KV Grid, and new grid stations are being added. Whenever this happens, the long feeders in close proximity fo the grid stations are bifurcated and connected to the substation by new feeder lines. a special provision is made in ADP for new feeders, which is never adequate. Distribution Wing gets barely 10% of Power Wing ADP and the backlog of new feeders is high.

This is an easy method of reduction of technical losses, which is noticeable in an any region where new substations have been constructed.

RENOVATION OF FEEDERS

Inadequate conductor sizes and voltage levels cause high technical losses. In most areas, particularly urban, the power demand has icreased. tremendoŭsly, and conductor sizes are entirely inadequate. Sometimes it may even be necessary to increase the voltage level. It has often happened in WAPDA system, that if conductor is not available in the stores, the Linemen have strung G.I. Wire which is technically criminal. The sections of G.I. Wire are being replaced with proper conductor now.

In suburban areas and "katchi-abadis", unauthorised long distribution lines have been strung on spliced wood and branches. Physical replacement of these lines is not difficult, but administrative procedures are tedious, as operation sub-divisions are reluctant to report such cases for fear of action against them.

Renovation is highly neglected. Firstly, meagre funds are allocated to this Head of account. Secondly, even these funds are not fully utilised for lack of incentives.

UNDERSIZED DISTRIBUTION TRANSFORMERS

Distribution transformers, particularly in dense urban areas easily get overloaded due to fast growth of power demand and new connections. This causes both deterioration in supply as well as higher losses. Due to lack of monitoring in WAPDA system, a distribution transformer

rarely gets replaced until it has completely burnt out.

Surprisingly, oversized transformers in rural areas, also add to technical losses. At-present, the smallest size of transformer is 25 KVA whereas many villages and tubewells have demand of less than 10 KVA.

Distribution transformers are entirely locally manufactured in Pakistan. Attracted by this lucrative captive business, many small manufacturers have got on the band-wagon, with the result that the quality has suffered. Technical specifications also need to be revised to provide for lower losses. These should not only be based on thermal criteria but on loss criteria, where a greater value should be assigned. Distribution Transformer Load Management (TLM) should be introduced. Unfortunately, these considerations receive very low priority in the operation divisions.

LOWER POWER FACTOR

Low power-factor on the distribution system is the major cause of technical losses. Tubewlll motors, induction motors in textile and other industries, electric fans and air-conditioners all contribute to low power-factor due to thehigh reactance of motors. Reactive power is also contributed by the generators, transmission and distribution lines. Low power-factor can be improved by installation of capacitors which results in:–

(i) Reduced losses

(ii) Better voltage regulation

(iii) Released generation, transmission and distribution capacity to serve other existing loads (and reduce the quantum of load-shedding).

(iv) Savings in investment by delaying the future additions in power system.

Power-factor control by installation of capacitors has high benefit-cost ratio. In the most optimal cases, this ratio is as high as 15.

Efforts have been made in the past to instal capacitors on 11 KV feeders. Somehow, our line-staff is highly allergic to the capacitors. They have a mistaken notion that frequent breakdown on the lines are caused by capacitors. They have therefore disconnected the capacitors and then the capacitors have disappeared, most probably stolen.

During the last year, concentrated efforts have been made to instal capactitors, this time within the compound of grid-stations. This is not the optimal situation since capacitors should be installed at the point of highest loading. However, the results in reduction of losses have been apparant. USAID consultants propose to educate the line staff on the use and efficacy of capacitors.

CONNECTIONS, ISOLATORS, DROPOUT FUSES, CONSUMERS SERVICES

Poor workmanship causes technical losses in this area. Most of WAPDA's line staff are either illiterate or semi-educated. Massive training of line staff would be necessary. Many line-men's training schools have been established. USAID consultants plan to train more than 25,000 Distribution Staff over a five-year period.

METERING

Although there are little or no technical losses in metering but slow operation of meters causes losses and these could be termed technical rather than administrative. Single-phase meters are entirely manufactured within the country. But manufacturers have stubbornly pursued a policy of manufacturing low quality meters either from East European Countries, Russia or China. Only recently, some meters of South Korean and Japanese components have been manufactured, but their proportion is small. These low-quality meters progressively run slower and should in any case be replaced in five to ten years time. It may be emphatically stated that with the passage of time, the meters can only run SLOWER and NOT FASTER. These low-quality meters run 3–5% slower after a few years and this is a considerable loss of revenue. That is the reason that a consumer complains of high billing after a faulty or old meter has been replaced.

It is estimated by the World Bank that technical losses in Distribution systems should never exceed 10% and the economically optimal loss in Distribution system can be as low as 5%.

Economic loss level for transmission can be as low as 8% by World Bank estimates.

10. NON–TECHNICAL LOSSES

Non-technical losses relate to pilferage of electricity, adminstrative errors in metering and billing, "fudging" various statistical returns and defective meters. These losses can be reduced to zero, as in fact, is the case in many developed and developing countries. In Pakistan, non-technical losses in WAPDA's power system are high and are a great cause of concern. The estimates of non-technical losses vary but these are atleast one-third of total distribution losses.

As already discussed, there are two major external causes responsible for increased pressure on non-technical losses:–

(i) Power tariffs have increased four-fold during the last decade which has increased the temptation to steal. Higher charges per KWH for the upper slabs of domestic consumption of electricity have increased the theft of electricity particularly in prosperous areas where air-conditioners are used.

(ii) Shifting pattern of electricity consumption from industrial to domestic consumers has also increased the non-technical losses.

In a society, where non-payment of Government dues has little stigma attached to it, the theft of electricity is widespread. In Baluchistan and tribal areas of NWFP, the people simply are not convinced that they should pay for electricity. In the tribal areas, the simplest solution would be to charge for bulk power supplied to the Agencies and this may be treated as additional privy purse to the Political Agents. In Balucahistan, whenever tubewells are disconnected, a law and order situation is created and immediate restoration of power is ordered. In interior Sind and parts of Punjab, some feudal lords exercise such powress that their arrears run for several years and the orders for disconnection of electricity cannot be implemented.

WAPDA is the largest revenue-earning enterprise in Pakistan with an annual revenue exceeding Rs. 1,112 crores during 1985-86. There are nearly 500 operation sub-divisions located throughout Pakistan (except Karachi area). In an economically poor society, where wealth exercises a high social status, the temptations are great, and WAPDA staff are allured to engage in malpractices. Distribution Wing in WAPDA has secured an average of 10% ADP, and it has remaind a neglected sector. Its ailments are accumulation of 25 years of neglect. The competent staff

was generally assigned to Generation, Transmission andPlanning. Distribution Wing were subjected to frequent inquiries, purges and retirements. This further reduced their morals. They were targets of public criticism, ridicule by press and a spate of anonymous complaints. WAPDA labour is unionised and has a great clout to undermine the authority of officials. They are also protected by a strong labour Union. All these factors have contributed to widespread malpractices and corruption. Whereas, it has generaly been felt that honesty should start from the base of the pyramid, it has been seen that appointment of an Area Board Chief Engineer with high reputation of integrity and honesty has led to reduction in losses. But there is no doubt that distribution Wing is highly vulnerable and protection from slander and accusations are necessary, if honest and capable Officers are to be attracted to the Distribution Wing.

According to the Ombudsman, the largest number of complaints relating to WAPDA emanate from metering and billing. Probably, the ultimate method to eliminate non-technical losses would be to do away with door-to-door metering by replacing it with remore-controlled metering located in the substation, where it would not be possible to tamper with it. This has already been developed and would be used on some large industries but its cost is prohibitive to use it on a large scale.

Non-technical losses and measures to reduce them in various categories are as follows:

INDUSTRIES

Severe checks are carried out on all indsutrial conenctions. Industries receiving power at 11 KV have a metering panel for WAPDA which is sealed. Many major industries have dedicated feeders from the substation, so that duplicate meters have also been installed. It can be stated that bulk supplies, licencees, state industrial enterprises, and major industries do not indulge in malpractices, mostly because there are no incentives and meter readings are carried out at the level of Xen's. All such industries are on two-part tariffs, and since fixed charges are high, there is greater amount of tempering with MDI meters. Since these are timing mechanisms, great ingenuity is employed to show lower MDI. Prize Bonds used to seal the panels are no problems because duplicate Prize Bonds bearing the same numbers have been forged. Some of these industries employ the services of retired WAPDA employees and they are always one step ahead.

Other indsutrial consumers above 70 KW have "A" type Antitheft Boxes (ATB'S) installed on the metering. As of March 1986, a total number of 5,320 ATBs had been installed out of 5,900 consumers in this category, a progress of 90% But the reliability of these figures is doubtful. Many ATB's have not been sealed, and they serve no useful purpose.

COMMERCIAL

All commercial consumers are required to have "B" type ATB's installed. Many of thse ATB's have been found to have lids missing or they have not been latched properly. Prize Bonds have sometimes not been pasted. The design of ATB's is now being improved, so that once closed, they can only be broken open. Only a small percentage of Commercial consumers are reported to have ATB's.

DOMESTIC

Only 3–phase meters are generally provided ATB's. Many influential consumers have protested on their installation and have complained about the nomenclature of "Anti-Theft-Box" which they consider derogatory. It is now proposed to call these security boxes.

TUBEWELLS

All tubewells are required to have ATB's. The figures of ATB's installed should be taken cautiously, as a very large number of these ATB's are reported to have no lids. This has been a cause of concern, and WAPDA have undertaken a survey of ATB's through private contractors to ascertain whether these ATB's have been properly installed.

SURVEILLANCE

This is essentially a deterrant. Military personnel have been acquired on secondment and after commercial training, they are deputed to the Area Boards as well as Chief Commercial Manager's office. The Central Surveillance Teams have been very effective. On an average of Rs. 15 Million. Recovery Tehsildars have also been appointed with each Area Board; They affect recoveries under Land Revenue Act. Their performance has not been very good in terms of actual recoveries but they have also been quite a deterrant. Magistrates have also been seconded to WAPDA who can decide cases of theft of electricity and award punishments.

METERING AND BILLING

This is a weak area of Distribution Operations. Meter Readers can play havoc with the consumers by declaring their meters as defective, or showing "locked" premises and charging an "assessed" consumption. They may not even take the readings and just present any fictitious figures which can cause harassment to the consumers. Often consumers join hands with the Meter Readers in return for favours. Meter Readers are largely responsible for non-technical losses.

Another problem is that adjustments are carried out after heavy bills have been presented. This results in sending wrong returns of units sold. Reliability of records showing Distribution Losses has often been challenged. This is indeed a vicious circle. Regular training of Revenue Staff is carried out and stringent measure are being adopted. New Commercial Procedures prepared by World Bank Consultants have been introduced but it would be sometime before results can be evaluated.

FEEDERWISE LOSSES

At present, the only positive way to control non-technical losses is to check them feederwise and hold SDO's and Line Supdts. accountable for high losses. During 1983-84, feederwise checking was introduced so as to identify and correct feeders with high losses.

AREA BOARD LOSSES AND REVENUES

There are eight Area Electricity Boards in WAPDA. Peshawar Region covers MWFP, Quetta Region covers Baluchistan and Hyderabad Region covers Sind except Karachi (KESC). Punjab has five Regions at Islamabad Gujranwala, Lahore, Faisalabad and Multan.

REGIONWISE/YEARWISE PERCENTAGE OF DISTRIBUTION LOSSES

Year	1980–81 %age	1981–82 %age	1982–83 %age	1983–84 %age	1984–851985–86 %age	%age
Lahore	27.6	27.1	25.7	24.9	22.6	21.0
Gujranwala	22.2	17.9	18.6	17.6	13.2	14.8
Multan	17.3	19.0	18.5	17.1	14.3	12.7

Year;	1980–81 %age	1981–82 %age	1982–83 %age	1983–84 %age	1984–85 %age	1985–86 %age
Faisalabad	13.4	11.2	10.2	10.2	9.0	9.7
Islamabad	6.5	10.7	10.4	11.2	9.4	9.2
Peshawar	31.2	30.8	30.5	30.6	29.2	28.9
Hyderabad	19.9	23.7	19.2	18.2	15.7	16.8
Quetta	42.8	35.7	35.0	33.6	27.3	29.2

Total revenue collection in 1985–86 was Rs. 11226 million which was divided in various Regions as follows:

Lahore	17.37%	
Gujranwala	13.13%	Punjab 74.45% (Rs. 8358 million).
Multan	15.96%	
Faisalabad	15.03%	
Islamabad	12.96%	
Peshawar	12.15%	NWFP 12.15% (Rs. 1365 million).
Quetta	1.45%	Baluchistan 1.45% (Rs. 159 million).
Hyderabad	11.95%	Sind (Except Karachi) 11.95% (Rs. 1342 million).

11. CONCLUSIONS

11. Energy Loss Reduction in WAPDA Power System is a colossal task and needs continusus efforts. There can be no sense of complacency. Although the losses have been brought down by 11% in 9 years tremendous efforts are needed to bring it down further.

RECOMMENDATIONS

The following recommendations evolve out of the case study:

(i) Rationalisation of power tariffs with particular reference to fixation of slabs for domestic tariff. Two-part tariffs for industry and tubewells to be optimised. Lifting of subsidies on tubewell tariffs to be considered.

(ii) To exercise some control on pattern of consumption. In order to curb tendency of excessive domestic consumption, air-conditioners should be subject to higher local excise duties and taxation. Other electrical gadgets which are wasteful of electricity consumptions should also be levied higher taxes, particularly electric heaters.

(iii) Adequate allocation of ADP funds to Distribution Wing should be ensured.

(iv) Reorganization of Distribution Wing with greater autonomy and accountability.

(v) Organisational analysis, job-definitions and setting objectives.

(vi) Improvement of Management Information System (M.I.S).

(vii) Extensive training at all levels of staff. Recognition of talent possessing higher educational qualifications and relevant experience. Career planning. Organised training in institutions.

(vii) Systematic data collection and mapping. Computerisation of network data, maps, loading of feeders and transformers, forecasting, long-range planning. Computerisation of designs.

(ix) Through familiarisation with computers by higher level Distribution Management.

(x) Monitoring and control of Distribution functions with the help of computers and models.

(xi) Energy conservation.

(xii) Reduction in long length of feeders.

(xiii) Optimisation of conductor sizes and voltage levels.

(xiv) Distribution Transformer load management (TLM).

(xv) Improvement of power factor by installation of capacitors.

(xvi) Use of high quality KWH meters.

(xvii) Reduction of non-technical losses by assigning staff with reputation of integrity and to protect them from unscrupulous elements.

(xviii) To improve the quality of tubewell motors, electric fans and induction motors.

(xix) To improve the design of distribution transformers.

(xx) To improve commercial procedures and to eliminate bogus and inflated bills, and their adjustment.

(xxi) To ensure correct returns of Energy losses.