# DISTRIBUTION LOSS REDUCTION AND EFFICIENCY IMPROVEMENT IN POWER DISTRIBUTION

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## INTRODUCTION

Technical losses in power systems occur due to energy dissipated in the conductors and equipment used for transmission, transformation, sub-transmission and distribution of power.

The technical losses in our power systems are high especially in the distribution systems.

This paper will help in describing the measures that can be taken to reduce the technical losses and overcome the existing deficiencies in the system to achieve the overall objectives. It is to understand that technical losses can be reduced and brought down to acceptable levels but cannot be made zero.

The causes of high technical losses are varied and require different remedial measures to be implemented to bring them down to acceptable levels. This paper will help in comprehending these measures for reducing technical losses to acceptable levels, in the Indian context.

## MEASURES FOR TECHNICAL LOSS REDUCTION

The short-term measures involve measures required for immediate improvement and reduction of losses in the system. These are based upon the information / data readily available with the utilities. The works proposed under this plan should be based on the sample studies/statistical check/scrutiny of the existing system details.

Short-term Measures for Technical Loss Reduction

- Network Reconfiguration
- Network Reconductoring
- Preventing Leakages at Insulators
- Employing AVB (Automatic Voltage Booster)
- Better Management of Distribution Transformers
- Load Balancing and Load Management
- Capacitor Installation (Shunt or Series)
- Improving Joints and Connections
- Laying Additional Link Lines
- Increase in HT:LT Ratio
- Adoption of High Voltage Distribution System (HVDS)
- Regular Maintenance of Distribution Network
- Creation of Primary Substation

A combination of one or more of the above measures would have to be taken to bring the losses down to acceptable levels. We describe these, in brief.

## NETWORK RECONFIGURATION

The Distribution Networks in developing countries have so far been expanded in an ad-hoc manner to minimize the initial investment cost. Generally, long range planning studies have not been undertaken. In such a situation, there exists vast scope for reconfiguring the network to minimize losses.

Network reconfiguration involves any one or all of the following:

a) Formation of new links to minimize the length of the trunkline within a feeder to form a tree structure.
b) Erection of interlinking lines to change the area of feed from one substation to another and balance the load among the substations.
c) Bifurcation of existing feeder to form parallel paths of power flow.

Through network reconfiguration, consumers can be fed by multiple sources by switching. Hence, it gives an option to handle the increased demand and increases system reliability. Network reconfiguration among feeders is effective only when the voltage drop between the nodes to be linked is rich and the distance between the nodes is short. The nodes to be linked have to be selected taking the quotient of voltage difference and the distance between the nodes as the criteria. Network reconfiguration within a feeder is effective only when the zigzag factor is high.

The Zigzag factor is defined as the ratio of total length of feeder to the bee line distance between the distribution substation and minimum voltage point.

The links have to be chosen so as to create a tree structure.

## NETWORK RECONDUCTORING

The size of conductor/cable is an important parameter as it determines the current density and the resistance of the line. A lower conductor size can cause high I2R losses (a technical loss that can be reduced) and high voltage drop which causes a loss of revenue as consumer's consumption and hence revenue is reduced.

Increasing the size of conductors will require additional investment, which may not pay back for the reduction in losses. The recommended practice is to find out whether the conductor is able to deliver the peak demand of the consumers at the correct voltages, that is, the voltage drop must remain within the allowable limits as specified in the Electricity Act, 2003. Network reconductoring is a preferred solution.

Network reconductoring is the replacement of the existing conductor on the feeder with an optimal conductor size for optimal length of the feeder.

This scheme arises where the existing conductor is no more optimal due to rapid load growth. This is particularly relevant for the developing countries, where the annual growth rates are high and the conductor sizes are chosen to minimize the initial capital investment. Studies of several distribution feeders indicate that the losses in the first few main sections (say, 4 to 5) from the source constitute a major part of the losses in the feeder. Reinforcing these sections with conductors of optimal size can prevent these losses. Thus, we can minimize the total cost, that is, the cost of investment and the cost of energy losses over a period of 5 to 10 years.

The sizing of conductor must depend upon the load it is expected to serve and other factors, such as capacity required in future. Alternate conductors/cables may also be considered wherever suitable. The total owning cost for the life of the line should be considered for evaluation of an alternative. The following options are available:

- Aerial bunched cable (ABC): ACSR is the most widely used conductor for lines constructed by conventional utilities. The use of ABC has the following advantages:
    i. Maintenance costs associated with these types of cable are reduced because clearing tree branches from the lines need not be as frequent.
    ii. These types of conductors are safer than bare conductors.
    iii. With ABC, it is difficult to tap the line without special piercing connectors because

of the insulation and the fact that the conductors are bundled.

- Armoured cable on pole: It is experienced that stringing an armoured cable on a messenger wire provides better security against hooking.
- Proper sized conductor in neutral: In distribution systems, a smaller size of neutral conductor is often used. This makes the neutral wire susceptible to high loss and breakdowns. The recommended practice is to use a conductor of the same size as that of the phase conductor. In case of cabled systems, the recommendation is to use a 4 core cable rather than a 3½ core cable, as the neutral must have the same current rating as that of the phase wires.

## PREVENTING LEAKAGES AT INSULATORS

Leakages at insulators, cracking of insulators and flashover across insulators often cause outages and results in loss of revenue. Pollution is a major cause for this damage. Due to pollution a deposit is formed on the insulator surface. The surface layer may absorb moisture and become semi-conducting causing leakage currents to flow. The surface gets heated and leads to an avalanche causing a flashover and cracking of insulator.

Use of appropriate material for insulators (like porcelain, glass, etc. depending on the nature of pollution in the local area) and designed protected creepage path helps in reducing insulator failure. Preventive actions are regular inspection and hot line washing, the latter being particularly suitable for coastal areas and areas with chemical industries.

## AUTOMATIC VOLTAGE BOOSTER

The functioning of Automatic Voltage Booster (AVB) is similar to that of the series capacitor. AVB is an on-load tap changer. It boosts the voltage at its point of location in discrete steps. This, in turn, improves the voltage profile and reduces the losses in the section beyond its point of location towards the receiving end. An AVB generally has a total voltage boost of 10% in four equal steps. The loss reduction is directly proportional to voltage boost.

The maximum permissible voltage boost is limited by the difference between the permissible maximum voltage and voltage at the point of location of AVB. The problem of determination of optimal location and percentage of boost of AVB is formulated as an optimization problem. The objective function is the cost of energy saved due to desirable constraint that the voltages at all sections should not exceed the statutory upper and lower limits. An interactive type of algorithm is adopted in the proposed solution approach.

## BETTER MANAGEMENT OF DISTRIBUTION TRANSFORMERS

The following measures can be taken:

- Augmentation/Addition of Distribution Transformers

Distribution transformers have to be augmented by installing additional transformers or increasing the capacity of the transformer when the maximum demand on the transformer is near its rating. It is always better to add a transformer than to augment. However, it may become expedient to augment in view of space constraints or right of way considerations.

- Relocation of Distribution Transformers at Load Centres

The location of transformers and type of transformers in the distribution system is strategically decided to ensure that losses are kept within optimum limits. Often distribution transformers are not located centrally with respect to the consumers. Consequently, the farthest consumers obtain an extremely low voltage even though reasonably good voltage levels are maintained at the transformers' secondary. This again leads to higher line losses. In order to reduce the voltage drop in the line to the farthest consumers, the distribution transformer should be located at the load centre to keep voltage drop within permissible limits.

- Low Voltage (less than declared voltage) Appearing at Transformers and Consumers Terminals

Whenever the voltage applied to induction motor varies from the rated voltage, its performance is affected. Against permissible voltage variation of ±6%, in practice, the supply voltage varies by more than 10% in many distribution systems. A reduced voltage in the case of an induction motor results in higher currents drawn for the same output. For a voltage drop of 10%, the full load current drawn by the induction motors increases by about 10% to 15%, the starting torque decreases by nearly 19% and the line loss in the distributor increases by about 20%. As the bulk load of rural areas and small scale industrial areas consists of induction motors, the line losses in the concerned distribution systems may even touch 20%. The above situation is corrected by operating an "on-toad-tap changing" in the power transformer situated at high voltage substations, 66/11 kV and 33/11 kV substations and providing on the 11 kV feeders, a combination of switched capacitors and automatic voltage regulators. Further, if the offload tap changing gear is available, the "off load tap changing" in distribution transformers is adjusted prior to the commencement of agricultural load season. This is readjusted before the on-set of monsoons when the rural load is small.

- Guarding Against Loss in Transformers

Distribution transformers are expected to convert up to 95-98% of the input power into usable output power. The distribution transformers installed in the distribution system get overloaded. Sizing distribution transformers to meet their expected loading greatly influences transformer efficiency.

Oversized transformers can contribute to inefficiency, but when transformers are appropriately matched to their loads, efficiency increases. However, when the transformer is very lightly loaded, the no-load loss of the transformer becomes a prominent part of the input energy and leads to a high percentage energy loss. Specifying a low core loss DT (like amorphous core transformers) can prevent high energy loss. Factors contributing towards losses in transformer are:

- Oversized transformers operating at low loading:

Improper selection of transformer based on its expected load and all day efficiency results in high no-load losses. The no-load losses in the lightly loaded transformers increase even more when facilities close for the day or on the weekend when most electrical equipment are turned off.

- Undersized transformers:

This causes higher loading on the transformer, resulting in higher operating losses.

- Unbalanced loads in secondary side:

There can be a significant unbalance in the system due to load imbalance in different phase, as more consumers may be connected to a particular phase. This results in neutral shifting, particularly depending on the solidity of grounding of the neutral. Neutral shifting can cause over fluxing (and burning of the transformer) due to higher voltage on certain limbs, and also higher technical loss. The overloading also leads to lower voltages at the consumer end and lesser energy consumption leading to loss in revenue.

- Connector at bushings:

There can be loose connection at bushings due to inadequate surface area for connections, and loose connections between the cables and bus bars. A recommended method is to have double bus bars to assure full utilization of the contact area. It is observed that over heating of connector at transformer bushing causes oil leakages on HT/LT bushings and with pollution deposits electrical leakages start at the bushing.

- Low oil level/oil leakages:

Transformer oil serves the dual purpose of insulation and cooling. Leakages of transformer oil and contamination of oil with moisture can reduce the insulation resistance (IR value) of oil. Sludge formation in oils can adversely affect the cooling and lead to higher temperatures and losses.

- Hot spots in core:

Hot spots can develop in the core due to the loosening of the core bolts. Hot spots in core can lead to eddy currents and higher core losses. Gas chromatography can be used to detect such potential hazards.

- Use of energy efficient transformers:

This can also help in preventing distribution losses. Recently distribution transformers with amorphous core have entered the Indian market and few utilities have installed these. The core losses (magnetizing or no load losses) get substantially reduced. However, the high cost is coming in the way for their large-scale use. Efforts are being made to make amorphous core material indigenously and the cost is expected to go down considerably.

## LOAD BALANCING AND LOAD MANAGEMENT

It has been observed that the load on all three phases of a distribution line and among the feeders is not balanced. This results in increased current in the heavily loaded line with increased line losses. If the loads on each phase or among feeders are redistributed, the losses will be reduced consumers for the overloaded phase should be done to reduce the imbalance in the system. The best method to identify unbalancing is to construct current duration curves for all three phases. In the scenario of overloaded distribution systems, load management plays a very important role for reduction of technical losses. Load management is important to ensure supply to feeders feeding critical emergency loads, curtailing supply to other loads and shifting of loads among feeders. To prevent overloading of lines and transformers in real time mode, modern features such as distribution automation may be incorporated. Distribution automation along with SCADA (Supervisory Control and Data Acquisition System) is an important tool for load management which should be introduced. You will learn about these in Block 3 of the course BEE-002.

## CAPACITOR INSTALLATION

The use of capacitors to correct for poor power factor is a well-established and cost-effective means of reducing distribution system losses and maximizing the revenue. Capacitor banks can be placed close to the low power factor loads, and other suitable locations for maximizing the system benefits in terms of releasing system capacity, controlling voltage and minimizing system losses. The capacitors should be a combination of switched and fixed type to prevent overcompensation. In certain States, the Regulatory Commissions have introduced kVAh tariffs to protect the interest of the distribution utilities and penalize for the poor power factors.

In most LT distribution circuits, it is found that the Power Factor (PF) ranges from 0.65 to 0.75. a low PF contributes towards high distribution losses. For low power factor the amount of current drawn increases to meet the same kilowatt demand of the load.

Thus low power factor results in higher currents throughout the system. Higher line currents result in higher losses due to the inherent resistance in the distribution lines.

Therefore, line losses owing to poor PF can be reduced by improving the PF.

Overall improvement in the operating condition can be brought about by reducing the system reactance. This can be done by the application of shunt capacitors.

Shunt capacitors can be connected in the following ways:

- Across individual customers;
- At vantage points on LT and 11 kV feeders;
- At distribution transformers; and
- At 33/11 kV substations.

Across individual customers: The most appropriate manner of improving PF of the distribution system and thereby reducing line losses is to connect capacitors across the terminals of the consumers having inductive loads. The extent of reduction of line losses in this manner depends mainly on the extent to which the PF of consumers is improved.

In this case, the capacitor is connected in parallel to the terminals, the capacitors being switched on and off together with the equipment itself.

Many electricity supply authorities are modifying their tariff conditions to make it compulsory for the consumers to provide capacitors for all types of installations with connected loads of 5 HP and above. Consumers are also being induced to improve PF either directly through high PF rebate in tariff or indirectly through kVAh based tariff, which penalizes low PF.

By connecting the capacitors across all individual inductive loads, it is observed that 10% voltage improvement, 20% reduction in current and reduction of losses up to 9% can be achieved depending upon the extent of PF improvement.

At vantage points on LT and 11 kV feeders: An unloaded distribution line is capacitive in character and a fully loaded line has inherent inductive and resistive characteristics. In distribution systems, especially those operating on low power factors, the inductive reactance makes a major contribution to the voltage drop. Usually it is the voltage drop consideration, which dictates the amount of power that can be distributed.

The optimum rating of capacitor banks for a distribution system is two-thirds of the average kVAR requirement of that distribution system.

The vantage point is at two-thirds the length of the main distributor from the transformer.

At distribution transformer (on the secondary side (LT side)):

Provision of capacitors at load point is found to be difficult in practice due to the additional investments required. It has also been experienced that the LT motive power consumers do not ensure the working of capacitors even if these are provided at the time of release of connections. The agricultural consumers are not keen to improve the power factor of their motors, as they are not benefited due to flat rate tariff. In addition, the consumers do not have requisite knowledge and skill to decide the level of compensation and check the availability.

While planning the distribution systems, such local practical problems can be taken care of by the power utilities by providing LT capacitors on distribution transformers. Switched or fixed capacitors at the distribution transformer are the next best alternative. The shunt capacitor supplies constant reactive power at its location, independent of the load. Therefore, optimal compensation provided for peak load condition may result in over compensation during light load conditions, necessitating automatic switching schemes.

Fixed capacitors are suitably chosen for light load conditions and connected permanently. The automatic switched capacitor bank of rating suitable for maximum kVA requirement of the concerned distribution system is installed with necessary provision of switching to suit the reactive demand of the system at any particular time. The switched capacitors can be switched off in steps and brought back in service as the reactive load on the system increases.

At 33/11 kV substations: 11 kV automatic switched capacitor banks are installed on bus of 33 or 66 kV substations. This has the facility that the required number of capacitor banks can be put in or out of the service depending on the requirement.

The maintenance of voltage at customer premises within statutory limits at all loads is the responsibility of utility. Series capacitors introduce negative reactance in the line and improve the voltage, which in turn also reduces the power losses. The main advantage of series capacitors is that the quantum of compensation is highly responsive to load current and series capacitors can be kept in the circuit during the complete load cycle, without causing any adverse effect of over voltages, during low load conditions.

## IMPROVING JOINTS AND CONNECTIONS

Improper joints are a source of energy loss in both overhead and underground systems. The conductivity of joint should not be less than an equivalent length of the conductor. Joints should be capable of carrying maximum fault current without failure or deterioration for the time required for the protective system to operate. The life of the joint should be equal to that of the conductors without deterioration either electrically or mechanically.

Bad workmanship contributes significantly towards increasing distribution losses. Efforts should, therefore, be made to have the best possible workmanship.

Joints are a source of power loss. Therefore, the number of joints should be kept to a minimum. Proper jointing techniques should be used to ensure firm connections. Quite often joints are made by wrapping the conductors with GI wires. In case PG clamps are used, the PG clamps should be of adequate size and GI nuts/bolts with spring washers should be used. All PG clamps need a re-tightening after around 1 year as the clamps become loose and a layer of coating gets deposited in the contact surfaces. It is, however, best to have sleeve joints and crimp the joints with a crimping tool. While making the joints, the two ends of the cut out stranded conductor will tend to get loose. The recommended practice is to wrap the loose ends tightly using GI wire before making a joint. Loose strands are often a cause for heating and related damage.

For mid-span joints, tension jointing of bundles in mid-span must be avoided. At erection, where a choice exists, the bundles must be joined at the non-tension bond position of a pole top.

For shackle joints, the jumper connector at shackle points is better with PG clamps but it is advisable to use crimped or fire wedge connections.

ii) Connections to the transformer bushing-stem, drop out fuse, isolator, and LT switch, etc. should be periodically inspected and proper pressure maintained to avoid sparking and heating of contacts.

iii) Replacement of deteriorated wires and services should also be made in a timely manner to avoid leakage and loss of power.

In addition, the following measures may be taken:

i. Spacing of poles: The spacing between poles (for overhead lines) is also an important requirement. Long spans will result in sagging of conductors with all its associated problems and should be avoided.
ii. Connections between overhead and underground system: The end terminations of the cables where the supply is tapped from the lines, although properly finished using good end termination kits, get deteriorated over time. This is due to continuous exposure to the different weather conditions in different seasons. The entry of water/ moisture into the cable damages the insulation of the cable, leading to cable faults and should be prevented.
iii. Outdoor termination for cables: Outdoor terminations for paper insulated or PILCA cables were generally used without much of a problem. With the advent of PVC cables, outdoor termination kits were no longer required. However, with the introduction of XLPE cables the same practice was continued. But the XLPE cables do not have ultraviolet stability like the PVC cables, a fact that is often overlooked. This results in cracking and pitting/pilling of insulation and can cause

breakdowns and even fires. Hence, connections between overhead and underground systems, particularly where XLPE cables are used, must be made inside specially designed termination units that protect the cables or the exposed XLPE insulation to sunlight. Care needs to be taken at the junction boxes as loose terminations can result in energy loss.

iv. Guarding against Losses in Service Cables and Connections: The service cables to consumer premises are often a source of loss that can be reduced. The length of service cables of all consumers taken together can be from 8 to 20 times the length of the LT distribution network.

Factors Contributing to Losses in Service Cables

- *Size of the cable*: Improper selection of cable size results in increased losses and lower voltage at the consumer premises leading to revenue loss.*Tapping of underground service cables*: The service cables must be visible so that tapping of cables can be detected. Underground service cables should be avoided as they are not visible for routine inspection.
- *Connections*: Loose connections of the service cables can result in sparking and is another source of avoidable energy loss.
- *Bimetallic connections*: Generally, the LT conductor is of aluminium while at many places the service cable is of copper. Connecting aluminium and copper creates a bi-metallic junction leading to corrosion, high resistance and failure. This should be avoided.
- Guarding against Losses due to High Impedance Faults: The high impedance faults result in avoidable technical loss and may also cause safety hazards in overhead system. High impedance faults are often caused due to trees touching the lines and bird nesting, etc. Regular line patrolling, tree trimming and removing bird nests are needed to prevent such faults.

  In underground cables high impedance faults may occur due to insulation pitting, breakdowns from digging, rodent infestation or ageing of cable insulation, formation of carbon trees, etc. Locating and repairing underground faults requires specialized equipment and training.

## INCREASE IN HT/LT RATIO

It is well known that for high HT/LT ratio, the losses will be low. The losses for a given quantum of power supplied by a line are inversely proportional to the square of its operating voltage. Higher the operating voltage, lower will be the line losses. Therefore, by increasing the HT lines the losses will be reduced.

Installation of lower capacity distribution transformers to serve a smaller number/cluster of consumers will result in increase in HT lines and decrease in the length of LT lines as HT lines will have to be taken nearer to the consumers. This will lead to reduction in losses.

## ADOPTION OF HIGH VOLTAGE DISTRIBUTION SYSTEM (HVDS)

Adoption of HVDS (High Voltage Distribution System) by converting existing LVDS to HVDS reduces the technical losses appreciably. The loads in rural areas are widely dispersed and to feed a small load, LT lines run for long distances. Prior to the introduction of HVDS, 11 kV, 3-phase lines were being run up to large sized 3-phase transformers 11 kV/433 V from which lengthy 3-phase LT lines were run. Such a system is not suitable for Indian conditions, especially in rural areas, as voltage profiles are poor, losses are high and outages in supply are also high. HVDS envisages running 11 kV lines right up to a cluster of 2 or 3 consumers, employing small sized distribution transformers (15 kVA) and extending supply to these 2 or 3 consumers with least (or almost nil) LT lines.

The High Voltage Distribution System could be of the following types:

- Extension of three phase HT line from the primary substation with installation of small capacity three phase transformers nearer to the load point.
- Extension of single phase HT line from the primary substation with small capacity single phase distribution transformers nearer to the load point
- Composite system with extension of three phase line from the Primary substation and single phase/ phase to phase. In a composite system, the main HV line is three phase construction from which spur lines are tapped to feed single phase loads.

High voltage distribution system can be implemented in various stages in a phased manner. HVDS has reduced losses, as the major part of distribution takes place at higher voltage. The system reliability is increased as the breakdown affects lesser number of consumers since they are fed from pole mounted single phase transformers. The main advantage is the improvement in voltage profile. Added advantage of the HVDS system is that it discourages"hooking" by consumers.

## PREVENTIVE AND REGULAR MAINTENANCE

Preventive and regular maintenance of components of the distributions system is necessary to reduce/eliminate breakdowns. Care should be taken to optimize preventive maintenance, because each shutdown due to preventive maintenance is also a source of revenue loss.

Preventive maintenance can be minimized by careful design and healthy installation practices. The following activities should be undertaken for preventive maintenance:

- Maintenance of overhead lines, which requires removing/trimming of trees along a sufficiently wide right-of-way to avoid their possibly damaging the line. The creepers and bird nests should also be removed.
- Repairing of broken or damaged cross-arms, insulators, conductors and supports should be done on a regular basis.
- Bending/leaning of poles should be corrected and stays should be tightened. Transformer oil testing for moisture level, BDV and sludge. In addition a periodic gas chromatography will help in identifying incipient/developing faults in a transformer.
- Improved bushings: High creepage distance bushings with 50% protected creepage can serve as a better solution. Having multiple connections at the bushing is a damaging installation practice causing higher outages.
- Monitoring the temperature of the transformer tank: In case the tank is hot, the transformer should be de-energized and tested.
- Rewinding of transformer: This always leads to higher no-load and operative losses. Higher losses after rewinding should not be permitted.
- Protective devices such as switches, circuit breakers, relays, fuse and lightning arrestors, etc. should be used to protect the distribution system and temptation to bypass it must be avoided.
- The neutral of the transformer should be solidly grounded to prevent neutral shifting and to allow the zero sequence currents to be earthed.

## ACCEPTABLE LEVELS OF TECHNICAL LOSSES IN DISTRIBUTION SYSTEM

Acceptable technical loss levels depend on economic factors such as costs of power and energy, costs of equipment and discount rates rather than purely on technical factors.

The achievable level of losses is subject to various factors such as

- configuration of the network;
- physical parameters of the network;
- level of loading; and
- prevalent operating voltage levels, etc.

However, with a view to meet the economic loss performance, target levels and maximum tolerable loss levels for each voltage level on the system may be taken as shown in Table below;

Table : Proposed Targets for Economic Loss Levels

| S. No. | System Component | Levels for Peak Power Losses | |
|---|---|---|---|
| | | Target Level% | Maximum Tolerable % |
| 1 | Step-up transformer and EHV transmission system | 0.50 | 1.00 |
| 2 | Transformation to intermediate voltage level, transmission system and step-down to subtransmission voltage level | 1.50 | 3.00 |
| 3 | Sub-transmission system and step-down to distribution voltage level | 2.25 | 4.50 |
| 4 | Distribution lines and Service connections | 4.00 | 7.00 |
| 5 | Total Power Losses | 8.25 | 15.50 |

## CONCLUSION

Technical loss reduction can be achieved by various measures such as network reconfiguration, network reconductoring, load balancing, capacitor installation (shunt or series), employing auto voltage booster, laying additional link lines, relocation of distribution transformers at load centres, augmentation of distribution transformers, addition of new distribution transformers, improving joints, increasing HT:LT ratio, adoption of High Voltage Distribution System (HVDS) and regular maintenance of distribution network.

The acceptable technical power loss levels are in the range of 8.25% to 15.5% depending on configuration of the network, physical parameters of the network, level of loading and prevalent operating voltage levels, etc. In the long-term, plans for phased strengthening and improvement of the distribution systems along with associated transmission system will have to be prepared and implemented on a regular basis.

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