Transmission and Distribution Losses (Power)

Introduction

In India, average T & D (Transmission & Distribution) losses, have been officially indicated as 23 percent of the electricity generated. However, as per sample studies carried out by independent agencies including TERI, these losses have been estimated to be as high as 50 percent in some states. In a recent study carried out by SBI Capital Markets for DVB, the T&D losses have been estimated as 58%. This is contrary to claims by DVB that their transmission and distribution losses are between 40 and 50 percent. With the setting up of State Regulatory Commissions in the country, accurate estimation of T&D Losses has gained importance as the level of losses directly affects the sales and power purchase requirements and hence has a bearing on the determination of electricity tariff of a utility by the commission.

Components of T&D losses

Energy losses occur in the process of supplying electricity to consumers due to technical and commercial losses. The technical losses are due to energy dissipated in the conductors and equipment used for transmission, transformation, sub- transmission and distribution of power. These technical losses are inherent in a system and can be reduced to an optimum level. The losses can be further sub grouped depending upon the stage of power transformation & transmission system as Transmission Losses (400kV/220kV/132kV/66kV), as Sub transmission losses (33kV /11kV) and Distribution losses (11kV/0.4kv). The commercial losses are caused by pilferage, defective meters, and errors in meter reading and in estimating unmetered supply of energy.

Level of T& D Losses

The officially declared transmission and distribution losses in India have gradually risen from about 15 percent up to the year 1966-67 to about 23 percent in 1998-99. The continued rising trend in the losses is a matter of serious concern and all out efforts are required to contain the them. According to a study carried out by Electric Power Research Institute (EPRI) of the USA some time

back, the losses in various elements of the T&D system usually are of the order as indicated below: -

System element	Power Losses (%)	
	Minimum	Maximum
Step-up transformers & EHV transmission system	0.5	1.0
Transformation to intermediate voltage level, transmission system & step down to sub-transmission voltage level	1.5	3.0
Sub-transmission system & step-down to distribution voltage level	2.0	4.5
Distribution lines and service connections	3.0	7.0
Total Losses	7.0	15.5

The losses in any system would, however, depend on the pattern of energy use, intensity of load demand, load density, and capability and configuration of the transmission and distribution system that vary for various system elements. According to CEA vide its publication (July 1991) 'Guidelines for Reduction of Transmission and Distribution Losses' it should be reasonable to aim for total energy losses in the range of 10-15% in the different states in India. The enclosed Annexure-B indicates the rising trend of T&D losses in the various states in the past. This can be compared with T&D losses in the other countries indicated in the enclosed Annexures-A. A glimpse of this Annexure indicates that in most developed countries the T&D losses are less than 10 percent.

Reasons for high T&D Losses

Experience in many parts of the world demonstrates that it is possible to reduce the losses in a reasonably short period of time and that such investments have a high internal rate of return. A clear understanding on the magnitude of technical and commercial losses is the first step in the direction of reducing T&D losses. This can be achieved by putting in place a system for accurate energy accounting. This system is essentially a tool for energy management and helps in breaking down the total energy consumption into all its components. It aims at accounting for energy generated and its consumption by various categories of consumers, as well as, for energy required for meeting technical requirement of system elements. It also helps the utility in bringing accountability and efficiency in its working.

Reasons for high technical losses

The following are the major reasons for high technical losses in our country: -

- Inadequate investment on transmission and distribution, particularly in sub-transmission and distribution. While the desired investment ratio

between generation and T&D should be 1:1, during the period 1956 -97 it decreased to 1:0.45. Low investment has resulted in overloading of the distribution system without commensurate strengthening and augmentation.

- Haphazard growths of sub-transmission and distribution system with the short-term objective of extension of power supply to new areas.
- Large scale rural electrification through long 11kV and LT lines.
- Too many stage of transformations.
- Improper load management.
- Inadequate reactive compensation
- Poor quality of equipment used in agricultural pumping in rural areas, cooler air-conditioners and industrial loads in urban areas.

Reasons for commercial losses

Theft and pilferage account for a substantial part of the high transmission and distribution losses in India. Theft / pilferage of energy is mainly committed by two categories of consumers i.e. non-consumers and bonafide consumers. Antisocial elements avail unauthorized/unrecorded supply by hooking or tapping the bare conductors of L.T. feeder or tampered service wires. Some of the bonafide consumers willfully commit the pilferage by way of damaging and / or creating disturbances to measuring equipment installed at their premises. Some of the modes for illegal abstraction or consumption of electricity are given below:

- Making unauthorized extensions of loads, especially those having “H.P.” tariff.
- Tampering the meter readings by mechanical jerks, placement of powerful magnets or disturbing the disc rotation with foreign matters.
- Stopping the meters by remote control.
- Willful burning of meters.
- Changing the sequence of terminal wiring.
- Bypassing the meter.
- Changing C.T.ratio and reducing the recording.
- Errors in meter reading and recording.
- Improper testing and calibration of meters.

T&D losses in restructured SEBs

Some states have embarked on programs of power sector reforms and have taken steps to restructure their SEBs (State Electricity Boards). The reforming states that were reporting T&D losses of around twenty percent before restruc-

turing process suddenly reported higher losses after carrying out detailed studies of their system. For example, before restructuring its power sector, Orissa reported 23 percent loss, after restructuring, T&D loss were shown to be 51 percent. In AP where these losses were of the order of about 25 percent before restructuring, it is now estimated to be around 45 percent after restructuring. Haryana has now estimated its losses at 40 percent and Rajasthan at 43 percent against earlier level of 32 percent and 26 percent respectively

Regulatory concerns

In the absence of a realistic estimate of T&D losses, it is not possible for the regulatory commissions to correctly estimate the revenue requirements and also avoid the situation where the consumers pay for the inefficiencies of the utilities.

In order to determine an appropriate tariff, the first step is to determine the justified cost incurred by the entity. This would provide an indication of the revenue requirement, which in turn is the basis of any tariff design. The regulator has therefore to be very careful about how losses are worked out.

The aim of the regulator must be to encourage the utility to make every effort to reduce losses while at the same time ensuring that those conditions applied which threaten the viability of the utility are not applied.

Barriers in private sector participation

The lack of realistic estimates of T& D losses acts as a disincentive for private sector participation in power distribution as the party can not have an idea of the realistic revenue potential of the area being privatized.

Unmetered supply

Unmetered supply to agricultural pumps and single point connections to small domestic consumers of weaker sections of the society is one of the major reasons for commercial losses. In most states, the agricultural tariff is based on the unit horsepower (H.P.) of the motors. Such power loads get sanctioned at the low load declarations. Once the connections are released, the consumers get into the habit of increasing their connected loads, without obtaining necessary sanction, for increased loading, from the utility.

Further estimation of the energy consumed in unmetered supply has a great bearing on the estimation of T&D losses on account of inherent errors in estimation. Most of the utilities deliberately overestimate the unmetered agricultural consumption to get higher subsidy from the State Govt.and also project

reduction in losses. In other words higher the estimates of the unmetered consumption, lesser the T&D loss figure and viceversa. Moreover the correct estimation of unmetered consumption by the agricultural sector greatly depends upon the cropping pattern, ground water level, seasonal variation, hours of operation etc.

To increase the food output, almost all the State Governments show benevolence to farmers and arrange supply of electric power for irrigation to the farmers at a nominal rate, and in some States, without charges at all. In view of this, most Electricity Boards supply power to agriculture sector and claim subsidy from the State Govt. based on energy consumption.

Since the energy supplied to the agriculture sector is a generous gesture by the State Govt., all the electricity boards have eliminated energy meters for agriculture sector services. The absence of energy meters provides ample opportunities to SEBs to estimate average consumption in agriculture sector at a much higher value than the actual. In the absence of energy meters, most of the SEBs resort to fudging consumption figures to include not only the under estimated T&D Losses but also energy theft from their system. The extent of fudging is more in the States where agricultural activity is high. The benefit derived by these boards is not only the extent of subsidy from the respective States but also self praise, by showing much less T&D losses. Further the boards are ignoring the inefficiency in operating the distribution system by blaming the agricultural supply for all ills and raising the tariff of other consumers.

Most of the methods being employed by SEBs for estimating the unmetered energy consumption are as follows: -

- Load factor based estimation.
- Estimation based on feederwise theoretical calculation of losses.
- Estimation based on readings of meters installed at all the Distribution Transformers located on a feeder.

However, none of the these methods provide correct estimation of unmetered consumption.

Measures for reducing technical losses

Short term measures

- Identification of the weakest areas in the distribution system and strengthening /improving them so as to draw the maximum benefits of the limited resources.

- Reducing the length of LT lines by relocation of distribution sub stations/ installations of additional distribution transformers (DTs).
- Installation of lower capacity distribution transformers at each consumer premises instead of cluster formation and substitution of DTs with those having lower no load losses such as amorphous core transformers.
- Installation of shunt capacitors for improvement of power factor.

Long term measures

- Mapping of complete primary and secondary distribution system clearly depicting the various parameters such as conductor size line lengths etc.
- Compilation of data regarding existing loads, operating conditions, forecast of expected loads etc.
- Carrying out detailed distribution system studies considering the expected load development during the next 8-10 years.
- Preparation of long-term plans for phased strengthening and improvement of the distribution systems along with associated transmission system.
- Estimation of the financial requirements for implementation of the different phases of system improvement works.
- Formulation of comprehensive system improvement schemes with detailed investment program so as to meet system requirement for first 5 years period.

Measures for reducing non-technical losses

According to the International Utilities Revenue Protection Association. (IURPA), research carried out on utilities worldwide indicates that service quality, customer relationships, and overall service satisfaction can minimize revenue losses. This has been demonstrated in Pakistan where rampant power theft has contributed financial crisis for WAPDA (Water & Power Development Authority). The World Bank and Asian Development Bank which had supplied the bulk of WAPDA's development loans wanted the authority to recover its unpaid dues, cut power theft and reduce its T&D Losses. Accordingly WAPDA was forced to raise power rates.

But instead of improving the financial situation, this action resulted in increased financial crisis of WAPDA due to increased incidence of theft and unpaid bills. In view of this, the authority applied extreme measures to curb power theft. The Chairman of the authority (a serving army officer) deployed 35,000 troops to tackle the crisis. The troops were instructed to identify and arrest people responsible for power theft. As a result of this more than 36

military courts began trying cases of power theft. There are a range of methods being employed by utilities the world over to mitigate power theft. Some of these measures are given below.

- Set up vigilance squads to check and prevent pilferage of energy.
- Severe penalties may be imposed on those tampering with the meter seals etc.
- Energy audits should be introduced and personal responsibility should be fixed on the district officers (executive engineers) for energy received and energy sales in each area.
- Installation of tamper-proof meter boxes and use of tamper-proof numbered seals.
- Providing adequate meter testing facilities. A time bound program should be chalked out for checking the meters, and replacement of defective meters with tested meters.

Initiatives required

Keeping the above in view it is very essential that immediate steps are initiated to have an assessment of the realistic T &D losses in each of the states and that immediate steps are taken to reduce the same in a systematic manner by all the players in the field.

- The central or the state governments should draw plans to provide financial support to the utilities for installations of meters on at least all the distribution transformers in a phased manner.
- It should be made obligatory for all the big industries as well as the utilities to carry out energy audit of their system to identify high loss areas and take remedial measures to reduce the same.
- Schemes for incentive awards to utilities who are able to reduce T&D losses beyond a certain pre-fixed limit.
- The financial institutions should be encouraged to provide easy loans to utilities for taking remedial measures to reduce the T&D losses.
- Publicity campaigns should be carried out to make the consumer aware of the high penalties on the unauthorized use of electricity.
- Utilities should prepare realistic power Master Plans for their systems to develop a strategy to meet the growing electricity demands of the different sectors of the state's economy over the next 15 years.

Issues for discussion

1. Status of metering and steps required for early installation of the same

In view of the financial assistance being provided by the Central government for installation of meters, the feasibility of achieving the proposed targets can be an important issue for discussion.

2. Mitigating power theft

Indian Electricity Act 1910 has been amended through Sections 39 and 39A to make theft of energy and its abetment as a cognizable offence with deterrent punishment of upto 3 years imprisonment.

Theft of electric power is a problem experienced in varying degrees by all electric utilities. The impact of theft is not limited to loss of revenue, it also effects power quality resulting in low voltage and voltage dips.

Adequacy of the existing measures to curb power theft could be an issue for discussion.

3. Implementation of energy audits schemes

It should be obligatory for all big industries and utilities to carry out Energy Audits of their system. Further time bound action for initiating studies for realistic assessment of the total T&D Losses into technical and non-technical losses has also to be drawn by utilities for identifying high loss areas to initiate remedial measures to reduce the same. The realistic assessment of T&D Loss of a utility greatly depends on the chosen sample size which in turn has a bearing on the level of confidence desired and the tolerance limit of variation in results. In view of this it is very essential to fix a limit of the sample size for realistic quick estimates of losses.

4. Setting of bench marks for yearly reduction of T&D losses (technical and non-technical)

References

1. Power Ministers Conference February 2000. – Agenda Notes

2. Electric Power International – Fall, 1999.

3. Guidelines for Energy Audit in Power Systems, CEA, New Delhi May 1992

4. P. N Khare MSEB, Power Theft – A Root Cause of T& D Losses

5. Mr.M.H.P. Rao 'Power Sector bogged down by T&D Losses' in Financial Ex-press, dated July 9 ,1999

Annexure A: Transmission and distribution loss

Country	T&D losses percent	Country	T&D losses percent
Japan	4.0	Switzerland	6.0
Denmark	4.0	Sweden	6.4
Germany	4.0	United States	7.0
Ghana	4.0	United Kingdom	7.0
Singapore	4.0	Taiwan	7.0
Guam	4.50[a]	Italy	7.4
Macau	4.81[a]	London	8.3
Korea	5.4	Malaysia	10.0
France	5.9	Thailand	10.3
Australia	6.0	Fiji	10.52[a]
Canada	6.0	Indonesia	12.0
China	6.0	Mexico	14.0
South Africa	6.0	Hong Kong	15.0

[a]Source is Electric Power in Asia and Pacific, United Nations, 1997

Source. World Development Report 1997, and London Electricity of UK

Annexure B: Transmission and distribution losses as a percentage of availability in state electricity departments: 1991/92 to 1999/2000

State	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97	1997/98[a]	1998/99[b]	1999/00[c]
Andhra Pradesh	20.3	19.2	19.1	18.9	18.9	33.1	32.5	31.9	31.1
Arunachal Pradesh	28.2	34.9	31.6	31.0	36.0	32.6	31.0	31.1	31.5
Assam	22.7	21.0	20.8	24.9	26.2	26.0	30.1	23.0	30.0
Bihar	18.3	20.5	19.0	24.0	25.9	25.3	25.4	39.5	36.0
Daman and Diu	15.9	0	0	0	0	0	0	0	0
Goa	23.8	20.8	21.8	26.2	28.5	23.5	23.4	29.1	23.0
Gujarat	23.6	21.1	21.3	20.0	18.3	21.4	21.7	20.1	18.0
Haryana	26.8	25.4	25.5	28.5	31.4	32.8	33.4	29.6	29.5
Himachal Pradesh	19.2	18.5	17.3	17.4	17.5	18.4	19.2	18.5	18.1
Jammu and Kashmir	50.1	45.3	47.7	46.9	48.6	50.0	47.5	43.8	46.5
Karnataka	19.3	18.7	18.6	18.9	18.5	18.9	18.6	17	18.3
Kerala	22.5	21.0	20.2	20.1	20.1	21.4	17.9	17.5	17.0
Lakshadweep	17.4	0	0	0	0	0	0	0	0
Madhya Pradesh	25.8	22.2	20.2	20.1	19.5	20.6	19.7	17.8	18.6
Maharashtra	18.6	16.4	15.8	15.3	15.4	17.7	17.1	17.3	17.0
Manipur	24.4	22.5	22.5	22.0	21.5	23.0	21.8	19.7	20.0
Meghalaya	11.7	12.2	10.7	18.7	17.8	19.5	17.9	18.9	19.0
Mizoram	34.9	28.1	28.0	28.0	27.0	34.4	25.7	42.0	43.0
Nagaland	23.1	32.4	31.6	30.8	30.0	26.8	29.5	29.0	28.5
Orissa	25.3	23.5	23.4	23.8	46.9	50.4	46.0	42.0	36.0
Punjab	21.8	18.7	18.5	18.3	18.2	18.9	17.8	17.1	17.7
Rajasthan	23.1	24.5	25.2	25.0	28.5	25.9	26.5	29.5	22.0
Sikkim[a]	25.9	21.8	21.5	21.2	21.0	29.2	20.1	20.0	19.8
Tamil Nadu	18.4	17.5	17.3	16.9	17.0	17.2	16.8	16.6	16.5
Tripura	32.0	30.5	30.0	30.0	30.0	30.1	29.3	28.5	28.0
Uttar Pradesh	26.1	24.1	23.2	22.6	22.8	25.1	25.5	26.3	22.9
West Bengal	19.7	23.7	22.4	21.1	20.7	20.1	20.0	19.5	19.0
All-India (utilities)	22.8	19.8	20.2	20.3	22.2	24.5	23.9	23.2	22.0

[a] provisional; [b] revised ; [c] estimate

Source. Planning Commission. 2000. Annual Report on the Working of State Electricity Boards and Electricity Departments. p. 66.