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Different Techniques of Loss Minimization in Distribution System

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Abstract: An electric distribution system plays an important role in achieving satisfactory power supply. The quality of power is measured by voltage stability and profile of voltage. But because of losses in distribution system, its voltage profile affects. Basically, the losses could be defined as the difference between the metered units energy input into the distribution system and the total energy paid that leaving the network through electricity accounts, whether calculated or estimated, in any given period. As, total distribution losses equals to sum of technical losses and non-technical losses. This paper presents various techniques to reduce these losses and their contribution in improving power efficiency of distribution system. Also, presents merits and demerits of techniques.

Keywords: Distribution system, losses, network reconfiguration, Automatic Voltage Regulator, HVDS.

I. Introduction

The final stage in the delivery of electricity to the customers is electricity distribution. A distribution system delivers electricity to the customers by carrying it from transmission system. It is, in many cases, the largest investment, maintenance and operation expense, and the object of interest to government, financial agencies, and associations of concerned citizens. About 30 to 40% of total investments in the electrical sector go to distribution systems, but nevertheless, they have not received the technological impact in the same manner as the generation and transmission systems[1]. In India, Transmission and distribution losses are among the highest in the world. The main reasons for high transmission and distribution losses in India are inadequate investment in transmission and distribution system. From 19.8% in 1992-93, the losses are increases to 33.98% in 2002. In 2009, the losses were approximately equals to 27.15%. Though the current average of Aggregate Transmission and Commercial losses in India is 28% and that there is wide variation in losses are seen in different states.

II. Losses in Distribution System

a. Technical losses: The losses that occurs naturally and depend upon the type of conductor used, transformer capacity, and other component used for transmission and distribution of electricity. These losses are inherent to the distribution of electricity and cannot be eliminated but can be reduced. These losses are stated as losses that occurs due to heat dissipation resulting from current paasing through conductors and magnetic losses in transformers.

b. Non-technical losses: The losses that occurs because of illegal consumption of electricity. These are caused due to discrepancy in reading of meters, theft of power, faulty meter and inefficiency in collection of bills. Non-payment, as the name implies refers to cases where customers refuse or unable to pay bill for their electricity consumption. It is estimated that electricity theft costs in our country is in crores in a year.

III. Reason For High T&D Losses

The main reson for a such high rate of T&D losses in the transmission and distribution system are the investments have been low in sub-transmission and distribution. While, in generation part the investment has increased steadily, transmission has not kept with generation part. Because of which there is mismatch in generation and supporting transmission system.

The other reasons for high transmission and distribution losses are used of lengthy distribution lines, unbalanced phases, use of poor quality of equipments, inadequate size of conductors, low power factor, etc. But in India, the major causes of T&D losses is power theft. Inefficiency in the power distribution system has led to failure in checking of power theft and this leakage continues to plague the sector. According to the Economic Survey of 2006-07, loss due to theft and pilferage is estimated to be Rs.20,000 crore annually.

Following table A show analysis of T&D losses in different states of India from year 2007 to 2012.

Table: Overall T&D Losses

State	2007-08	2008-09	2009-10	2010-11	2011-12
Andhra Pradesh	20.3	19.2	18.1	16.1	15.3
Arunachal Pradesh	43.7	48.0	39.1	35.6	34.5
Assam	28.0	29.6	34.8	29.9	27.7
Bihar	39.1	38.0	38.3	37.0	35.0
Chhattisgarh	31.0	28.6	38.7	34.7	32.7
Goa	16.7	21.0	16.6	17.4	17.6
Gujarat	23.8	22.8	24.5	22.7	22.3
Haryana	28.1	25.7	26.8	24.4	22.7
Himachal Pradesh	13.5	13.2	14.7	14.6	14.5
Jammu & Kashmir	61.9	61.3	63.0	60.0	58.5
Jharkhand	42.3	43.0	38.5	33.5	40.8
Karnataka	25.3	23.3	21.4	20.1	19.6
Kerala	19.9	19.9	19.2	19.1	18.6
Madhya Pradesh	40.1	39.0	35.6	34.1	32.6
Maharashtra	29.1	26.5	25.2	22.5	21.6
Manipur	48.4	51.1	45.8	43.3	38.0
Meghalaya	33.4	31.2	34.0	30.0	28.4
Mizoram	24.9	32.6	37.0	35.4	34.3
Nagaland	36.4	31.0	36.5	30.8	28.1
Puducherry	13.8	13.7	13.5	13.5	13.5
Punjab	21.5	18.5	19.7	17.8	16.8
Rajasthan	35.5	31.9	29.9	27.6	24.8
Sikkim	22.3	34.0	40.6	42.4	38.8
Tamil Nadu	18.0	18.0	18.0	18.0	17.0
Tripura	23.4	24.1	24.7	20.9	20.1
Uttar Pradesh	32.6	28.6	32.3	28.9	24.4
Uttarakhand	29.7	28.0	24.5	22.5	20.5
West Bengal	24.3	23.3	23.8	23.5	22.3
Source: Planning Commission					

From above table, it is seen that power utilities should take mandatory steps to reduce losses in Transmission and Distribution system. Many authors have discussed loss minimization in T&D system in different ways.

IV. Loss Reduction Techniques in Distribution System

The various loss reduction techniques are:

a) Network Reconfiguration and Phase Load Balance.
b) Network Reconductoring
c) Distribution Transformers Locating and Sizing

VOL. 2 ISSUE 2, FEB.-2013 ISSN NO: 2319-7463

d) Automatic Voltage Booster
e) Reactive Power Compensation
f) Aerial Bunched Cables
g) High-Efficient Transformer
h) High Voltage Distribution System
i) Building New Substation

a) Network Reconfiguration and Phase Load Balance

Network reconfiguration is the one of the possible methods in distribution system for reducing losses in which the power flow is altered by the formation of new links within a feeder to form tree structure or by opening or closing the appropriate switches on the feeders. And by forming new links to the change area of feed from one substation to another , balance the load among the substation. Network Reconfiguration is the process of operating switches to change the circuit topology so that operating costs are reduced while satisfying the specified constraints[1].

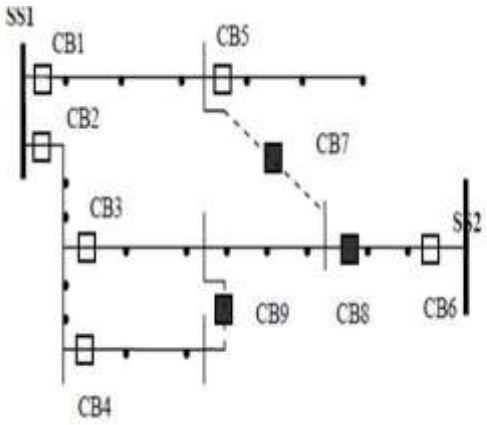

Fig. 1 simple example of network reconfiguration

Merits:

- Restoring power to any outage partitions of a feeder,
- Reducing overloads on feeders by shifting the load in real time to nearby feeders, and
- Resistive line losses will be reduce.

b) Network Reconductoring

Network reconductoring is the technique in existing conductor on the feeder is replaced by conductor of optimal size for optimal length of feeder. This technique is used when existing conductor is no more optimal because of rapid growth of load. This technique is good for the developing countries like India where annual growth rates are high and the conductor are chosen to minimize the initial capital investment.

Merits:

- This techniques increases the feeder's capacity to handle load growth.
- It is extremely fruitful to minimize the losses.
- It improves voltage profile.

Demerits:

- This technique leads to additional investment which increases the initial investment of feeders.

c) Distribution Transformers Locating and Sizing

Usually, DTs are not located centrally with respect to consumers. Due to which the farthest consumers obtain an extremely low voltage even though a reasonably good voltage level is maintained at secondaries of transformer. This leads to higher losses in distribution system. In this technique, distribution transformers should be located nearer to the load center as possible and replace large transformers by the transformers of small rating such that it serves small number of consumers so that optimum voltage level is maintained **.**

VOL. 2 ISSUE 2, FEB.-2013 ISSN NO: 2319-7463

Merits :

- It supports further reconfiguration.
- This technique requires less investment.
- It helps in reduction of peak load and energy losses in the distribution sytem.
- It improves voltage to the tail end consumers.
- Overloading of conductors and overheating of joints avoided.

Demerits:

- The extent of improvement of voltage is limited.
- For further improvement of voltage profile, other methodologies have to be adopted which involves extra investment.

d) Automatic Voltage Booster (AVB)

Automatic Voltage Booster increases the voltage at its point of location in discrete steps which in turn improves profile of voltage and redces the losses in the sections beyond its location point towards receiving. Generally, AVB boost voltage upto 10% in equal steps. Loss reduction is directly proportional to voltage boost.

Merits:

- As it reduces the voltage drop by 10%, therefore, it is very effective tool to solve voltage drop problem.

Demerits:

- The reduction of losses with the use of AVB is marginal and as such rate is poor.

e) Reactive Power Compensation

It is defined as the management of reactive power to improve the performance of ac power system. This technique clasp a diverse and wide area of both system and customer problems, particularly related with power quality issues, as most of power quality problems can be resolved with requisite control of reactive power. As the load is mostly inductive on the distribution system and requires large reactive power. As, shunt capacitor provides reactive power compensation at its location, independent of the load and Series capacitor introduces negative reactance. It means series compensation modifies the transmission or distribution system parameters, while shunt compensation changes the equivalent impedance of the load . In both cases, the reactive power that flows through the system can be effectively controlled improving the performance of the overall ac power system [2].

Merits:

- It improves the voltage profile.
- It reduces losses to very much extent.
- It also increases the security of system.
- It also reduces number of outages.

Demerits:

- It is difficult technique as compared to others as there is problem in determining the number and size of capacitors to installed and where to installed and lengthy process.
- The voltage improvement due to shunt compensation is marginal except in case of heavily loaded feeders. Shunt compensation alone cannot correct voltage drop.

f) Aerial Bunched Cables (ABC)

These cables are novel concept for over head power distribution. It provides higher safety and reliability, reduces power losses and ultimate system economy by reducing installation, maintenance and operative cost. This technique is ideal for rural distribution distribution and especially attractive for installation in difficult areas such as hilly areas, forest areas, coastal areas etc.
This is also considered as best choice for power distribution congested urban areas with narrow lanes and by-lanes. ABC is the better choice in urban complex because of flexibility for rerouting as demand by changes in urban development plan.

Merits:

- Lower voltage drop, higher current capacities.
- As compared to bare conductors these cables are much safer .
- Total line costs are reduced
- Maintenance is very easy.
- Longer spans and longer distance lines are possible with better system stability.
- It reduces theft of electricity as it covered by insulated material.

Demerits:

- Intial capital cost is high as compared to bare conductors.

g) High Efficient of Transformers

The use of high efficient of transformers will also reduces losses, i.e using amorphous core transformers instead of CRGO transformers. As it have high magnetic susceptibility, with low coercivity and high electrical resistance. As in transformers, the high resistance leads to low losses by eddy currents.

Merits:

- It reduces CO_2 emission.
- It reduces core losses.

Demerits:

- It increases capital cost of power system.

h) High Voltage Distribution System (HVDS)

This technique is most effective and efficient in reducing the technical losses and improving the power quality in distribution system. In this technique, conversion of existing Low Voltage Distribution System to High Voltage Distribution System is done. This technique aims at extending high voltage lines as nearer to the load as possible and replacing large transformers with various small rating transformers. By using high this method, we can reduce the losses as current is low in high voltage systems.

Merits:

- It reduces losses, increases enrgy saving and improves voltage profile.
- It also reduces the theft of electricity and decreases illegal connections as the LT lines are reduced and required will be insulated cables.
- It also helps in avoiding unnecessary iron losses in overrated DTs and hence reduces technical losses.
- It also reduces the number of outages.
- It makes distribution system more reliable.
- It will bring the commercial viability in the power system.

Demerits:

- It requires additional investment.
- It needs regular maintenance.

i) Building New Substation

In this loss reduction technique, a new substation is constructed in addition to the existing one. Location of the new substation is determined by feasibility study. This scheme has to be adopted as the last option.

Merits:

- It is more reliable.
- It improves voltage profile and reduces losses.

Demerits:

- It increases capital cost as it requires additional investment for building new substation.

Conclusion

The various aspects of loss minimization system are discussed in this paper. Their merits and demerits and their contribution in improving power efficiency are also discussed in this paper. These techniques can be studied clearly by applying these techniques on any existing substation**.**

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