Energy Efficient Distribution Transformers

Emerging Trends in Distribution Sector

Electricity is one of the most vital infrastructure inputs for economic development of a country. The demand for electricity in India is enormous and is growing steadily. This growth has been slower than country's economic growth. To balance this demand and supply of electricity, it is the time for electric utilities to go for energy efficient electrical equipment for huge savings as this would be utilized for future needs.

The Ministry of Power has outlined its mission for 11^{th} Five Year Plan – "Power For All: 2012". In the next 5 years, India will require 66,000 MW of new generation capacity with matching investments in transmission and distribution networks. For every 1 MW of new capacity that comes up, about 7 – 8 MVA transformers (approximately) are used across Generation, Transmission and Distribution segments. This implies a demand of about 5,00,000 MVA of transformers unfolding over next 5 years, resulting in an annual demand of about 100,000 MVA, which would mean that there would be approximately a demand for 2.25 Million Transformer units (approx. 30% for distribution) of average rating of 63 kVA. Besides fresh demand, some replacement demand of 15,000MVA (approximately) will also be coming up, as transformers usually have a life of 20 – 30 years.

The 10^{th} Five Year Plan originally envisaged 41,100 MW, re-revised finally to about 30,500 MW and has ended at 23,450 MW. Simultaneously, with the worsening power scenario and acute power shortage, the Indian Economy cannot sustain the growth momentum but has to look for aggressively augmenting power supply.

The strategy developed to make power available to all by 2012 includes promotion of energy efficient products and its conservation in the country, which is found to be the least cost option to augment the gap between demand and supply.

Case: Typical loss comparison of a 63kVA Distribution Transformer

63KVA – Distribution Transformer	Ordinary Conventional Transformer	Energy Efficient Transformer	
		3 star	5 star
Max. Total Losses at 50% loading (watts)	490	380	280
Max. Total Losses at 100% loading (watts)	1415	1250	1100
Difference in power savings at 100% loading (watts)	1415 – 1250 = 165 (3 star) 1415 – 1100 = 315 (5 star)		

Nearly 185 to 354 MW (considering 50% of 2.25 Million transformers) of capacity creation through energy efficiency in the distribution sector alone is required in our country and this can be achieved only through employing Energy Efficient Distribution Transformers by our Electrical Utilities as transformer is the heart of any electrical distribution system.

The Distribution Reforms were identified as the key area to bring about the efficiency and improve financial health of the power sector.

Power utilities improve efficiency of their distribution systems by reducing losses. Industrial and commercial users of electricity also improve the efficiency of their electrical distribution systems by reducing losses. The distribution transformer supplies power to all the power consuming items and remains energized for 24 hours. Being supply equipment, it does not, by itself, consume any power. But the process of transformation involves certain inherent losses especially in the core, having to run continuously for all the 24 hours of the day and 365 days of the year. Hence we need to turn our attention to low loss designs and latest technologies in quality of core material to promote energy efficiency. In this context “amorphous metal core” material offers great advantage, as no load losses are less.

The scope for improving the efficiency of distribution transformers can arise in a number of ways. Higher performance raw materials, particularly special steels for building transformer cores, are continually being developed. Advancement in the core material, amorphous iron, produced by cooling molten metal alloy very rapidly, has become available and is getting wide acceptance in many utilities in India and across the globe. Losses in the core are less than 30% as compared to those of conventional steel cores. The size of the transformers being installed in the network, and the way in which they are loaded, can also increase savings. Transformers are at maximum efficiency when approximately 50% loaded.

T & D losses in India are high, in the range of 20-23 percent. The Ministry of Power says that aggregate technical and commercial (AT & C) losses are around 50% - and losses are even higher than this in some of the states.

The main reason for exceptional high losses in the Indian network lies at the distribution levels. Hence, the use of energy efficient equipments for the utilities is very much essential for reduction of losses, which implies for savings in electrical energy for its growing demand.

Over many years there has been a lack of investment in essential improvements to the electricity system, with only lowest cost incremental investments being undertaken. With this kind of purchasing system, especially for transformer at distribution sectors of State Electricity Boards in India, it would be unmanageable for them to meet the electricity demand of our economic growth.

Many electrical utilities have obligations to ‘operate an economic and efficient system’, but therein lies a conflict. ‘Economic’ suggests low capital cost transformers, which are not the most efficient, whereas ‘Efficient’ transformers come at higher prices.

Transformer manufacturers are aware of the commercial pressures on customers not to apply loss capitalization strictly and have to respond to these, particularly in a competitive market. A common ploy is to tempt the customer with a low cost / high loss alternative offer.

Total Owing Cost takes into account not only the initial transformer cost but also the cost to operate and maintain the transformer over its life. This requires that the total owing cost (TOC) be calculated over the life span of the transformer. With this method, it is now possible to calculate the real economic choice between competing models.

The TOC method not only includes the value of purchase price and future losses but also allows the user to adjust for tax rates cost of borrowing money, different energy rates, etc.

TOC = C + NLL x A + LL x B

Where,

TOC = capitalized total owing cost,

C = the initial cost of the transformer including transportation, sales tax and other costs to prepare it for service.

NLL = no – load loss in watts,

A = capitalized cost per rated watt of NLL (A value)

LL = load loss in watts at the transformer’s rated load

B = capitalized cost per rated watt of LL (B value)

Thus Total Owing Cost (TOC) method provides the Electrical utilities an effective way to evaluate various transformer initial purchase prices and cost of losses. The goal is to choose a transformer that meets specifications and simultaneously has the lowest TOC. The A and B values include the cost of no-load and load losses in the above TOC formula.

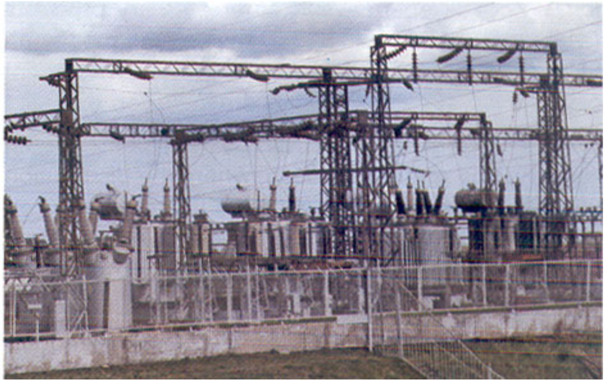
Even though the more-efficient transformer costs more initially, its lower operating cost saves money over its life.

Considering the vast potential of energy savings and benefits of energy efficiency, Bureau of Energy Efficiency has come up with reasonable solutions for strengthening and up gradation of the transformers used in the distribution system.

Some of the short term and long term measures taken by BEE

- Bureau of Energy Efficiency operationalized complete pilot phase of programme for energy efficiency in government building and prepare action plan for wider dissemination and implementation.
- Standards and Labeling (S&L) Programme has been identified as one of the key activities for energy efficiency improvements. The S&L program ensures that only energy efficient equipment would be available for purchasers. Some of the electrical products to be covered under S&L program are: Agricultural pump sets, Distribution Transformers, Motors, Lighting products, refrigerators, etc.

Energy – efficiency labels are informative labels fixed to manufactured products, which describe the product's energy performance (usually in the form of energy use, efficiency, or energy cost) and rate the product on a comparative scale so that consumers can make appropriate decisions while purchasing electrical equipments. Energy-efficiency Standards are procedures and regulations that prescribe minimum efficiency performance standards of the manufactured products.



BEE has taken lead role to network with and ensure participation of stakeholders such as industry associations, R&D institutions, manufacturers, Bureau of Indian Standards, etc. at all stages in the entire process.

- Facilitate and assist manufacturers to develop testing procedures and protocols for determining energy performance, label setting, fixing of standards, and enforcement mechanisms.
- Encourage manufacturers to improve energy efficiency of equipments and appliances at the manufacturing stage. Promote integration of efficient technology in manufacturing of equipment and appliances.
- Stimulate market transformation and promote energy efficient equipment and appliances.

The benefits of the approach and activities would be the following:

- Manufacture of energy efficient equipments and appliances.
- Enabling consumers to exercise considered choice based on energy consumption at the time of purchase.
- Reduction of energy consumption in equipments and appliances of common use.

With this, some of the electrical equipment manufacturers are fixing tie – up with distribution utilities to penetrate into the pool of promoting energy efficient equipments.

To exemplify the above statement, there has been a tie-up between CFL maker and distribution utility which entail distribution to domestic consumers for using less energy than other ordinary products (such as incandescent bulbs), saving their money on utility bills and helps in protecting the environment over the life of each CFL and draw carbon credits.

The project has already been kick-started in Haryana and Andhra Pradesh, where the distribution utilities have tied-up with CFL manufacturer, Osram, under a CDM-based scheme. (As per State Government officials – published in The Hindu Business Line dated 21.06.2007)

BEE has recently approved the 'star labeling' for Distribution Transformers – The highest loss segment is defined as star 1 and lowest loss segment is defined as star 5.

The existing IS 1180 (part 1) specification losses are the base case with star 1.

This demonstrates that the Centre is encouraging the electrical equipment manufacturers to come up with energy efficient products for their fullest utilization in energy savings.

Selection of better material for energy efficient transformer

In selecting the material for core, we say that amorphous metal core outflanks in reducing the no-load losses. This can summate immense economic savings to the electric utilities since they are one of the highest energy efficient transformers rated so far.

A typical comparison is shown below which depicts the decrease by installation of energy efficient low loss amorphous metal core transformers.

Rating (Three Phase)	CRGO (in watts)	AMDT (in watts)	Reduction in Losses
25 kVA	100	32	68%
50 kVA	160	58	64%
100 kVA	260	85	67%
200 kVA	470	115	75%

The above losses are indicative based on some design (Vijai Electricals Ltd).

Losse reduction due to non-linear loading (i.e. harmonic distortion): Use of best quality core material like Amorphous Magnetic alloy offers great advantage not only at fundamental frequency but, the advantage increase manifold as the distortion in both load current and supply voltage increases. There is increase in total loss and decrease in efficiency with higher distortions, but this phenomenon is affecting this core material much less as compared to Transformer with poor quality core.

A 3 phase, 250 kVA Transformer was tested under non-harmonic and harmonic conditions and the values noted down are as follows:

Without Harmonic Distortion

Losses	AMDT	CRGO
Hysterisis (A)	99	155
Eddy Current (B)	33	311
Total Core Loss (C) = (A+B)	132	466
Coil Loss (D)	966	1084
Loading	55%	58%
Total Loss (C + D)	1098	1550

With Total Harmonic Distortion of 26%

Losses	AMDT	CRGO
Hysterisis (A)	99	155
Eddy Current (B)	74	698
Total Core Loss (C) = (A+B)	173	853
Coil Loss (D)	1553	1671
Loading	55%	58%
Total Loss (C + D)	1726	2524

Thus, it is very evident form above tables that AMDTs (Amorphous Metal Distribution Transformers) are no doubt superior and offer a better technology at our disposal.

Rapid growth in large regional economies such as China and India has elevated human prosperity. However, unless ultimately decoupled from fossil-fuel use, such growth also threatens to exacerbate the climate challenge. Increased attention is however now being focused on the savings which Energy–Efficiency Transformers could make on a national scale and their potential contribution to meeting internationally agreed goals for reducing global warming. As for the environmental benefits, the high-efficiency transformer will contribute in reducing greenhouse gas emissions by reducing the consumption of fossil fuel necessary to accommodate excessive transformer losses.

Thus, improving efficiency of distribution transformers is very much in need for our country to balance the demand and supply of electricity by 2012 and in coming years, resulting in huge savings to the utility, by chopping the running cost of the transformer.

Reference Book:

IEEMA Journal
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