Lower losses reduce capitalised prices

New designs of transformers will pay for themselves on loss savings alone says H. W. Kerr, BSc, FIEE, technical director of Bonar Long.

Large numbers of transformers owned by the electricity board are approaching the end of their economic lives. It is widely conceded that at some stage a policy on replacement will have to be formulated and implemented if an unmanageable failure rate, with its associated costs, it not to occur.

A few electricity boards have formally budgeted replacement programmes for overhead lines, cables, switchgear and so on, and are implementing them. However, most boards have not yet included transformers in their programmes, but a recent change in the electricity supply industry's capital evaluation standards makes the economic case much more compelling. This change is the 1983 increase in the assessed cost of transformer losses.

The total cost of the transformer to the customer includes not only the manufacturer's price, but the cost of losses throughout its life. The cost of the losses depends on the loading and the length of life assumed, as well as energy costs throughout that life.

Transformers are usually permanently energised. Even in industrial situations, where plant is closed down over weekends or holiday periods, the transformers are rarely switched out since they are required for essential supplies. At current electricity prices of say 2.6p/kWh, each year's operation costs £227.76 for each kilowatt of no-load loss.

The load loss, on the other hand, depends on the duty of the transformer. In most cases the load will not be constant, and since the load loss varies as the square of current, this load profile must be taken into account.

Typically the annual cost of the load loss is between 5 and 25 per cent of the no-load loss.

Transformer tenders are usually evaluated on the manufacturers' price plus depreciation and interest charges, and the cost of the losses. About £4,000 is at present being assigned to each kilowatt of no-load loss by electricity boards, and values ranging from £200 to £700 are assigned to each kilowatt of load loss.

These figures, introduced in 1983, are about 50 per cent up on those previously used with the result that several companies have developed and are now marketing transformers with very low losses showing significantly lower capitalised prices.

Older transformers, and particularly those built before the introduction of cold-reduced steel cores, have losses much higher than those of modern designs. Further, the transformer core interlamination insulation materials used in the 1950s and earlier do not have the life of current materials, so that the actual in-service no-load loss of older transformers today is well above its original value—a deterioration of 10 per cent is widely accepted as a typical figure.

With these increased no-load losses set against the new assessment of the values of losses, it might now be economically justifiable to replace these old transformers containing hot-rolled steel cores with new very low loss ones.

A number of factors must influence the decision. Some of the more important ones are:

- ☐ Revenue savings from reduced *actual* losses;
- ☐ Maintenance cost reduction;
- ☐ Cost of removing and replacing old transformers;
- ☐ Scrap value of old transformers;
- ☐ Reduced risk of failure of supply to consumers;
- ☐ Phasing of capital expenditure; and
- ☐ Phasing of workload on engineering, planning and installation teams to contain manning levels required.

Comparison of the *actual* losses of 1950s hot-rolled steel core transformers today with those in the latest designs shows that, for distribution transformers and most system transformers, the capitalised value of the losses saved is about the same as the manufacturer's price of the new transformer. Thus the new transformer pays for itself on loss savings alone.

The cost of removing and replacing the old transformer, net of the scrap value, has thus to be justified only by the reduction in maintenance costs, the reduced risk of supply failure and the benefits of phasing capital expenditure and staff workload in the organisation of the transformer operator. The latter points are best evaluated by an expert from the supply industry, but it is clear from the comparison of engineering standards today with those of the 1950s that maintenance costs on modern transformers are much lower than those on their earlier counterparts. This is particularly important now when many electricity boards have reduced their maintenance manning and are running their transformers at higher ratings. In this more demanding regime equipment which is not sound (and relatively maintenance-free) will soon become more troublesome.

The bulk of the e.s.i.'s distribution transformer population was installed after the widespread introduction of cold-reduced core steel.

However, about 24 per cent of the population is 25 or more years old and contains high loss hot-rolled steel cores. Indeed around 5 per cent of the population is more than 40 years old. In the case of system and grid transformers these proportions are somewhat higher.

The experience of some other public utilities might convince the electricity supply industry that its already high equipment standards need to be maintained by new investment if its record of service to consumers is to continue.

Prudence and good stewardship require that replacement policies be extended to, or introduced for, transformers. The economic case is now clearly strong enough for such policies to set out the planned replacement over the foreseeable future of all the high-loss transformers incorporating hot-rolled steel cores. ☐

This diagram illustrates strikingly the assertion that modern very low transformers pay for themselves when replacing units containing hot-rolled steel cores (about 25 per cent of the U.K. transformer population).