DISTRIBUTION DEVELOPMENT AND REHABILITATION PROJECT OF THE C.E.B.

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In the previous issue the existing system loss levels and the resulting drawbacks as well as the overall arrangements presently being made to rectify the situation were discussed. The article is continued with a description of the technical and economic evaluation methods being used in the formulation of the proposed developments.

STUDY OF ALTERNATIVE DEVELOPMENT PROPOSALS

The characteristics of the selected area of study consisting of the existing line particulars and loading data form the basic data for the study. If possible the loading on each section during night peak, day peak and base load times are determined for each supply or distribution transformer within selected line sections. The expected load growth data for each line section also need to be estimated. The above system data is then computerised either through the digitizer or by keying in from a terminal. The ability of the present system to supply the load (if necessary with altered switching configurations) can now be studied. Further the loss levels as well as the ability to extend feeders for exigency conditions are obtained from the studies.

The next step is to set out a number of alternative development proposals to establish a more efficient

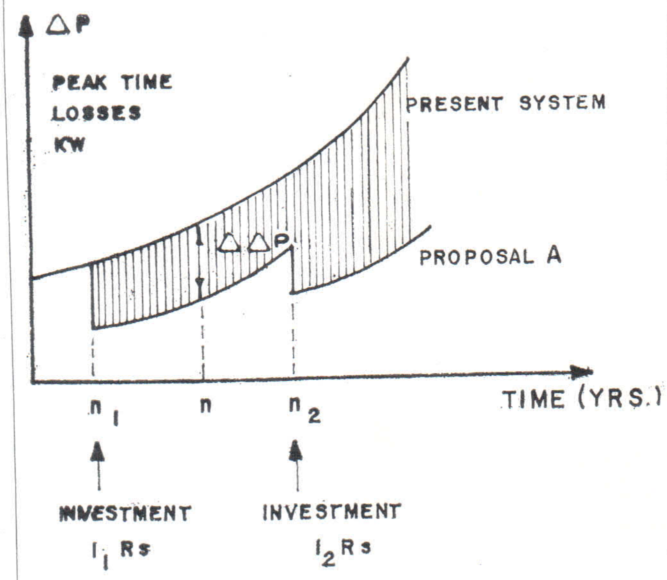

FIG I

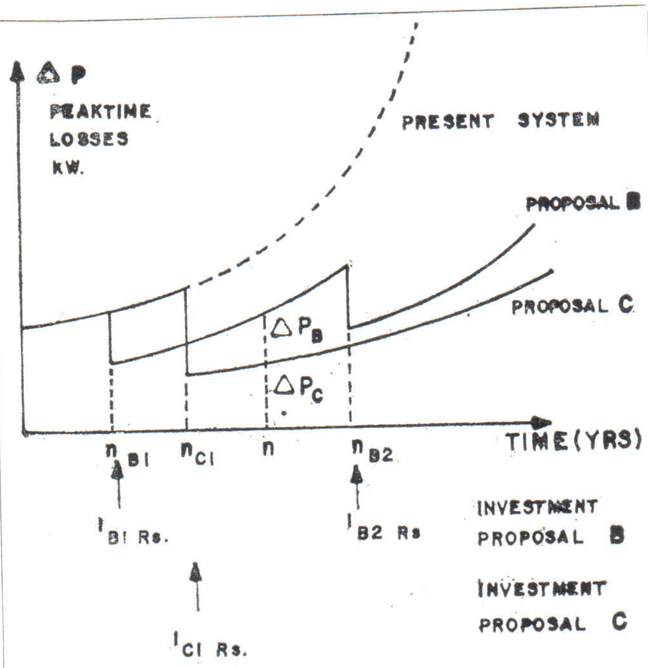

FIG 2

and economical distribution network. Each construction item in an alternative has two degrees of freedom.

(*a*) The physical configuration (such as conductor size, line route etc.)

(*b*) Timing of the investment.

Figure 1 shows a single proposal A, (consisting of 2 separate investments acting in two different years) compared with the present system for peak time power losses. Figure 2 shows two different proposals B and C in comparison with the existing system. In proposal B the losses are reduced due to certain investments $1B_1$ and IB_2 applied in years IB_1 and IB_2 respectively. In proposal C the single investment IC_1 is applied in year NC_1.

A selected set of such construction items with specified physical details and given timing would constitute a single alternative proposal. A particular alternative will thus have a specified system configuration at each year during the period of analysis. A number of such alternative proposals are established and each alternative is checked to determine whether technical criteria such as voltage drops and thermal rating of lines and equipment are satisfied. This is done by conducting load flow studies in selected years during

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the period of analysis. The alternatives which satisfy technical criteria are then selected for economic evaluation. This consist of establishing a present worthed 'net cost' table for each alternative. The net cost comprise of :

- (a) the investment cost.
- plus (b) cost of losses.
- less (c) additional reliability benefits attributable to the alternative.

3. COST OF LOSSES

The cost of losses are evaluated in terms of the L. R. M. C. values for capacity and for peak and off peak energy. For each feeder the load duration curve is determined or assumed and the loss load factor for peak time and off peak time is determined. The peak time losses are then converted to cost figures as follows :—

ΔP_m = Peak time power losses obtained from load flow studies.
C_p = Capacity costs in Rs / kw / yr.
E_p = Peak time energy costs in Rs / kwh. / yr.
E_o = Off-peak energy costs in Rs. / Kwh
L_p = Peak-time loss load factor.
L_o = Off peak loss load factor.

Cost of losses per year

$$= \Delta P_m . C_p + \Delta P_m . 8760 . L_p . E_p + \Delta P_m . 8760 \, L_o \, E_o$$
$$= \Delta P_m [C_p + 8760 . \, L_p \, E_p + 8760 \, L_o \, E_o]$$

The above expression provides a multiplying factor to convert the peak time power losses to total annual loss costs. If the system load flow studies are conducted for every year in the period of analysis the cost of losses could be worked out from the above expression and discounted to present value (with respect to the interest rate used). However in most cases the load flow studies need only to be conducted for certain years. In such cases the cost of losses for the intervening period discounted to the beginning of the period could be obtained by the series.

$$1 + \frac{(1+a)^2}{1+d} + \frac{(1+a)^4}{(1+d)^2} + \ldots + \frac{(1+a)^{2n-2}}{(1+d)^{n-1}}$$

where a = the load growth rate in p.u.
and d = discount rate in p.u.

The value of the above expression could be obtained from discounting (or compounding) tables by using the discount rate of $\frac{(1+a)^2}{1+d} - 1$

4. VALUE OF RELIABILITY BENEFITS

Every alternative would have an optimum feeding arrangement for the feeders in the system which would be shown by the load flow studies. Studies are also made to determine the additional loads that could be connected to a feeder in the event of failure of other feeders. The capacity to absorb such additional loads give a reliability benefit for that particular alternative. These benefits are evaluated by assuming reliability levels to the various feeder loads for each alternative.

for r = increased p.u. reliability level
P = associated load in Kw
LF = load factor of system.
E = Cost of energy (an average value between peak time and off peak LRMC costs for energy)
and X = a multiplying factor representing the value of saved outages with respect to energy costs.

The reliability benefits = P.8760. LF. r. E. X.

The factor X depends on the importance of the load area considered. For normal MV system a factor 5 has been used in the present studies while for important loads the factor has been increased to 10. The reliability benefits for a particular period is summed up by using normal discount tables and the present worth and the total reliability benefits for the total period of analysis is obtained.

5. An Application Example — Uprating an 11 Kv System to 33 Kv

In the study of the medium voltage network in the areas of Nittambuwa and Veyangoda the possible benefits of converting the 11 Kv network to 33 Kv was considered. Loss reduction benefits were assessed by use of the formular given in section 3. The load duration curve for the areas under consideration gives the peak time loss factor as 16% and the off peak loss factor as 23%. The L. R. M. C. value of capacity is 4000 Rs. / Kwh, and the energy costs are 1.65 Rs. / Kwh at peak time and 1.40 Rs. / Kwh at off peak time. This gives the cost of losses per year as Rs. 9134 ΔP_m (where ΔP_m is the peak time losses in Kw). It is also assessed that the conversion to 33 Kv would give an increase of system reliability by 1% which at a load factor of 59% and value of reliability at 5 x LRMC average energy rate of Rs. 1.50 gives, the annual reliability benefits —

$$= P + 8760 \times 0.59 \times .01 \times 5 \times 1.50 \text{ Rs./Kw}$$
$$= .387 \text{ Rs./Kw.}$$

where P is the load subjected to the reliability benefit.

The above figures for annual benefits of loss reduction and reliability together with the load flow results which yield the peak time losses and the ability to take up the exigency loads provides the evaluation table given below for the period 1987 to 2000. It is thus seen that the conversion of the 11 Kv network under consideration to 33 Kv is justifiable since a benefit to cost ratio of approx. 3 : 1 can be obtained.

BENEFIT TO COST ANALYSIS

CONVERSION OF 11KV. DISTRIBUTION OFF NITTAMBUWA & VEYANGODA PRIMARY SUBSTATIONS

		1987	1988	1989	1990	1995	2000
Losses (KW) With Pr SS.		126	132	151	167	289	565
Losses (KW) 33 KV System		57	66	76	87	180	377
Loss Saving (KW)		69	71	75	80	109	188
Cost of loss saving (Rs. 000's)		630	648	685	731	996	—
Adjustment for Multiple Periods		—	—	—	3442	4689	—
P. V. of Loss Savings (Rs. 000's)		461	428	406	1841	1486	—
Total P. V. of Loss Savings (Rs 000's)	= 4622						
Exigency Benefits (KW)		2348	2488	2638	3141		
Value of Exigency benefits (Rs. 000's)		895	948	1005	1196		
Adjustment for Multiple Periods		—	—	—	6622	(up to 2000)	
P. V. of Exigency Benefits (Rs. 000's)		655	625	596	3543		
Total P. V. of Exigency Benefits (Rs. 000's)	5419						

Cost of conversion 11 KV. to 33 KV	(Rs. 000's)	= 4699
P. V. of Conversion cost	(Rs. 000's)	= 3440

Benefits 1987 to 2000

P. V. of Loss reduction Benefits	(Rs. 000's)	= 4622
P. V. of Reliability Benefits	(Rs. 000's)	= 5419
Total Benefits	(Rs. 000's)	= 10041
Benefit to cost Ration		= 2.9 : 1