OVERALL COST COMPARISON BETWEEN CABLE AND OVERHEAD LINES INCLUDING THE COSTS FOR REPAIR AFTER RANDOM FAILURES

Roberto BENATO, University of Padova, (Italy), roberto.benato@unipd.it
Domenico NAPOLITANO, Free lance, (Italy), dominik99zz@yahoo.it

ABSTRACT

The paper deals with the comparison between the overall whole-of-life costs of overhead lines (OHL) and those of underground insulated cables (UGC). Almost all the investigations published so far, when analysing maintainability issues, take into account only the costs of planned periodical maintenance; here, a method for assessing also the expenses sustained for repair after random failures is proposed. The number of random failure events for each kind of component over the whole service life of a transmission line can only be predicted on probabilistic basis: its expected value is estimated by making use of the mean values of relevant failure rates from recent statistical surveys.

The whole procedure is shown by carrying out a particular case study as an example; nonetheless, the method may be widely applied to any type of OHL-UGC comparison.

KEYWORDS

Overall cost comparison, Underground cables, Overhead lines, Repair cost.

INTRODUCTION

Since the market introduction of cross-linked polyethylene (XLPE) extra-high voltage (EHV) cables, the high investment costs of EHV UGCs (which can be increased by shunt reactive compensation) were often taken as an argument to prefer an OHL "a priori", without consideration of the sensibly different economic burden brought about by OHLs and cables. Meaningful differences concern the impact of a new line on territory and the energy losses over the lifetime. The role of these factors has gained importance in recent years [1] because of both increasing safety & ecological constraints on territory and more stringent grid energy-efficiency requirements. Consequently, suitable criteria were introduced into the economic analysis in order to evaluate costs & benefits emerging from these issues. The authors have already published a general method for carrying out a comparative economic analysis between OHLs and UGCs [2, 3, 4] which takes into account:

- capital costs (I);
- UGC shunt compensation investment cost $(\Delta I)_{Sh}$;
- loss energy costs (E);
- burden on territory (T);
- dismantling costs (D);
- operation & maintenance costs (OM).

In this paper the procedure has been further developed in order to take into account also the costs for repair after random failures. These costs (in general consisting of a capital component for substitution of the faulted item and of a work component for on-site installation of the spare) are supposed to be incurred for each type of component with an average frequency, whose value is estimated from significant statistic collected by means of surveys on performance of large samples of operating components [5,6].

COMPARATIVE COST ANALYSIS BASED ON OVERALL COST Σ

Since the overall cost comparative procedure has been thoroughly described in the literature [2, 3, 4] it will be not here repeated but only briefly resumed.
The kilometric OHL overall cost Σ_O is given by

$$\Sigma_O = (I)_O + ((E))_O + (T)_O + ((D))_O + ((OM))_O + ((R))_O \quad [\text{M€/km}]; (1)$$

whereas for XLPE UGC it can be written as

$$\Sigma_U = (I)_U + (\Delta I)_{Sh} + ((E))_U + (T)_U + ((D))_U + ((OM))_U + ((R))_U \, [\text{M€/km}] (2)$$

The parameters involved in (1)-(2) are the following:

L [km]	Route length;
n *[year]*	Nominal lifetime of circuits;
$(I)_O$ [M€/km]	OHL capital cost per kilometre (including wayleave agreements: land purchase/lease charges);
$(I)_U$ [M€/km]	(XLPE) UGC capital cost (including wayleave);
$((E))_O$; $((E))_U$ [M€/km]	Discounted cost of energy losses for OHL and UGC, respectively;
$(T)_O$ [M€/km]	Burden per kilometre of OHL "corridor" ($=F_O \bullet 10^3 \bullet w_x$);
$(T)_U$ [M€/km]	Burden per kilometre of UGC "corridor" ($= F_U \bullet 10^3 \bullet w_x$);
F [m]	Width of the "corridor" along the entire line route according to laws, guidelines or standards;
w_x [€/m^2]	Economic value of the "corridor": average value along the link;
$((OM))_O$; $((OM))_U$ [M€/km]	Discounted cost of O&M (Operation & Maintenance);
$((R))_O$; $((R))_U$ [M€/km]	Discounted expected costs for repair of random failures;
$((D))_O$; $((D))_U$ [M€/km]	Discounted end of life dismantling cost.

Each cost pertains to a specified fiscal year of the nominal life (n=40 years) of the examined circuits. In the proposed case study, the capital expenditure for equipment supply and installation, for rights-of-way (ROWs) acquisition, for land purchases and for all civil works at site is assigned to the project initial year, y=0. On the opposite, costs for circuit decommissioning & dismantling pertain to the "end-of-life" year. On the other hand, annual operational (above all, energy losses) and maintenance/repair costs pertain to every year of the circuit service life. Once each cost component has been attributed to the pertinent year, its present value (i.e. discounted back to the start of the line life) is calculated. In this way, an effective comparison between the overall whole-of-life costs of the two cases is possible. Of course, a suitable interest rate must be chosen. Commonly, the Weighted Average Cost of Capital (WACC) is used as a rough estimate of the rate of interest per monetary unit of capital; hence, it provides a