Review of Advanced Transmission Technologies towards the Smart Grid

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I. Introduction

The significant increase of electric power flows, caused by notable changes in the power system structure such as competitive energy markets, development of large-scale wind power farms as well as a larger impact of technical and legislatives restrictions on the allowable load current of the existing distribution and transmission network has been observed over the last decades [2]. For adapting to the current situation two general ways can be implemented:

- ✓ There is a need to build new high voltage overhead lines (OHL), which requires considerable investments as well as causes a significant impact on the environment;
- ✓ There are cases of implementation of new advanced technologies into the existing transmission line infrastructure as well as using the traditional methods.

II. The Main Directions of Advanced Technologies

There is use of the traditional methods, for example, reconductoring transmission line or replacing terminal equipment; increasing the operating line voltage; building a new power line; conversing existing single circuit line to double circuit [7]. However, the progressive re-engineering of the existing power networks requires the innovative transmission technologies, which will be able to adapt to new concepts of operation and management of Smart Grid.

The main advanced technologies can be sub-grouped into four main clusters: Passive equipment, for example, Cross-Linked Polyethylene (XLPE) underground cables, Gas Insulated Lines (GILs), High Temperature Low Sag (HTLS) conductors, High Temperature Superconducting (HTS) cables; Active equipment, for example, Phase Shifting Transformers (PSTs), High Voltage Direct Current (HVDC), Flexible Alternating Current Transmission System (FACTS) and Fault Current Limiters (FCLs); Real Time system monitoring equipment (RT) as well as the Impacting TSOs' Operations equipment (ITO) [8].

VI. Case Study

There is an example of the optimization of the transmission line design based on a real project. In this study the optimization task of a structure and parameters of particular power line was formulated and implementation of one of advanced transmission technologies (passive equipment) such as HTLS conductors was assessed. The twenty alternatives were selected, formed by realizing the different combinations of examined towers and conductors (see Fig. 4).

Fig. 4 shows the optimum solution results of two-objective optimization by implementing Pareto approach [34], where I_C (p.u.) is the invested capital and E (kV/m) is the strength of the electrical field. As a result, the competitive variants are V6, V7, V9, V10, V15, V17, V19 and V20. Analysis of the competitive alternatives reveals the following:

- If the "classical" problem formulation, namely minimization of the invested capital, complying with all the restrictions would be used, one of the alternatives V10 would be chosen, which means that in this case traditional type conductors (ACSR) are economically justified as compared with the other combination of HTLS conductors. The final decision would be taken using one of the criteria in [33];
- If the constraint violation is allowed one of the alternatives V17 or V19 should be chosen, here it can be concluded that replacing the ACSR conductors with the HTLS conductors is now an effective solution due to low invested capital.

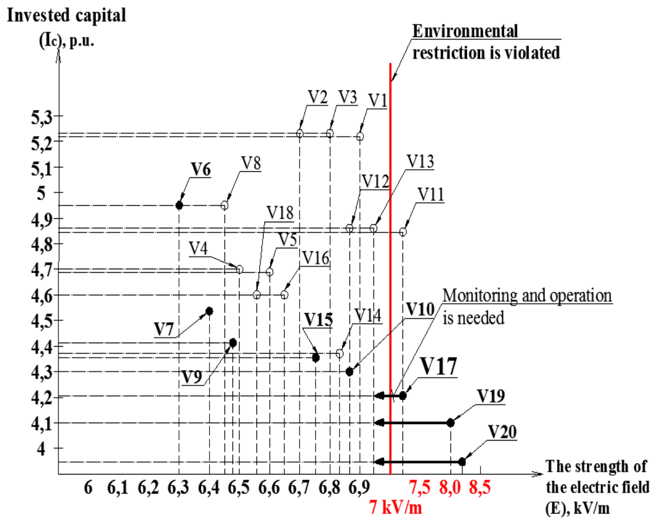

Fig. 4. The diagram of Pareto set for the combination variants

VII. Conclusions

The paper reflects an analysis of advanced transmission technologies that must be reviewed due to necessity for increasing the limited capacity of existing transmission grid. Moreover, the case study presents an evaluation of using HTLS conductors as compared with conductors of the traditional type. As a result, it was revealed that use of ACSR conductors is more effective solution in particular case study. Yet at the same time, implementation of such advanced technology as HTLS can be more economically justified if the price of these conductors is reduced.

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