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Matsyshyn V.V., student
Khalimovskyy O.M., Ph.D., Dozent
Igor Sikorsky Kyiv Polytechnic Institute, o.khalimovskyy@ukr.net

ANALYSIS OF FACTORS FOR ASSESSING THE SELECTION OF THE POWER TRANSMISSION LINE TYPE

In the modern context of increasing energy consumption and growing reliability requirements for power supply, selecting the "optimal" type of power transmission line (PTL) is of particular importance. The high efficiency of power grids is a key factor in ensuring a country's energy security [1]. Considering the impact of various technical, economic, and environmental factors, the choice between cable and overhead PTLs remains a relevant issue that requires in-depth analysis and justification.

Cable and overhead PTLs play a crucial role in modern energy systems. Their selection depends on numerous factors. The implementation of advanced technologies enhances the efficiency and reliability of both types of PTLs. The development of new materials helps reduce energy losses, improve resistance to external influences, and make power transmission safer and more efficient.

Modern research focuses on improving PTL [2] efficiency, particularly by exploring new insulation materials that minimize energy losses. Additionally, advancements in overhead PTLs aim to enhance protection against weather conditions and integrate intelligent monitoring systems to reduce failure rates.

The primary objective of this study is to develop a methodology for evaluating the selection between cable and overhead PTLs based on a comprehensive assessment of factors that determine power supply efficiency and reliability.

During the design of power grids, the choice between cable and overhead PTLs [3] is made considering a combination of technical, economic, and operational factors. Both options have their advantages and disadvantages, which affect energy transmission efficiency, operational costs, and environmental impact. Cable transmission lines are more commonly used in urban and densely populated areas due to their lower susceptibility to external factors. In contrast, overhead PTLs are more cost-effective for transmitting electricity over long distances.

When designing PTLs, it is also necessary to consider the prospects of introducing new materials and technologies that can improve power transmission efficiency and reliability.

Cable PTLs are installed underground or underwater and consist of multi-layer insulated conductors. They are primarily used in urban environments or in locations where overhead PTLs are not feasible. The main advantages of cable PTLs include immunity to weather conditions, long service life (up to 40 years), and reduced electromagnetic pollution. However, cable PTLs also have disadvantages, such as high construction costs, complexity in repair and damage diagnostics, and limited transmission capacity due to thermal losses.

Overhead PTLs are installed on support structures and are used for long-distance power transmission. Conductors are suspended from supports using insulators. The key advantages of this type of PTL include lower construction costs (compared to cable PTLs), ease of maintenance and repair, and high transmission efficiency over long distances.

Technical regulations [4] establish requirements for the protection of overhead PTLs against weather conditions, such as icing and wind, electromagnetic radiation, and potential damage due to other external factors. The service life of overhead PTLs is generally shorter than that of cable PTLs. Compared to overhead PTLs, cable PTLs are less susceptible to electromagnetic radiation.

The development of a methodology for selecting the structure and type of PTL for power supply based on a comprehensive assessment of influencing factors will make it possible to determine the most efficient PTL option when making project decisions [5]. The study analyzed the impact of the type of network structure and the selected type of lines (cable or overhead) on the following

key indicators: active power losses, reliability and operating costs. The analysis used modeling in MATLAB/Simulink and Mathcad environments, taking into account typical conductor parameters, network topology, load and climatic conditions.

Active power losses are calculated using the formula:

$$P = 3 \cdot I^2 \cdot R$$

where I - is the phase current;

R - is the resistance of one phase wire.

In addition to energy losses, it is important to consider the level of reliability. In ring and mixed networks, backup power is provided, which reduces recovery time after failures. Cable lines (CL) in such configurations have shown the highest reliability, but require high investments.

Figure 1 shows a typical fragment of a ring network using cable lines.

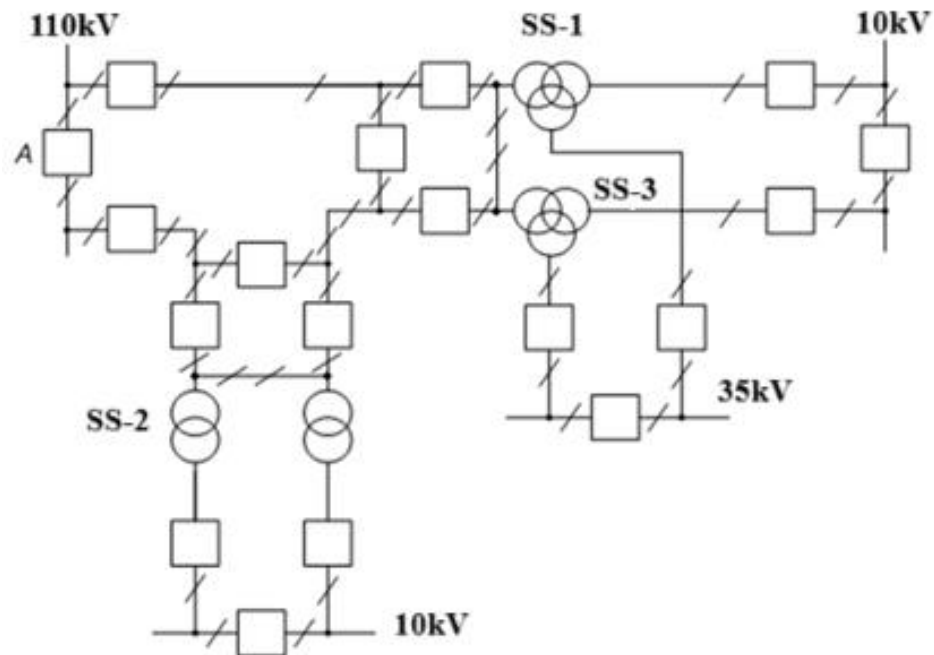


Fig. 1 – Ring power supply scheme with transformers at 110/35/10 kV substations (SS)

Thus, optimizing the structure of electrical networks should take into account not only the type of transmission line, but also the topology of the network. Mixed and ring networks with CL allow achieving the best balance between losses, reliability and long-term costs.

References

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