

Fuzzy Modeling of the Effects of Effective Factors on Non-technical Loss Reduction of Electrical Energy Distribution

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Abstract

The objective of the present study is to design a framework for evaluating the impact of factors influencing the reduction of non-technical losses in electrical energy. The research method employed is exploratory-theoretical modeling, which has been practically implemented and validated within the West Azerbaijan Power Distribution Company. Through the analysis of non-technical loss statistics and expert interviews with professionals in the electricity distribution sector, the factors of “consumption damage” (arising from both overt and covert unauthorized electricity usage) and “consumption difference” (resulting from the replacement of faulty meters and calculation errors) were identified as system inputs, while “non-technical losses” of electrical energy were defined as the output of the proposed fuzzy system. Various membership functions—including Gaussian, bell-shaped, S-shaped, Z-shaped, and triangular—were utilized to determine the degree of membership for verbal input and output variables within fuzzy sets. By applying 21 final rules and considering the centroid of fuzzy sets, the system was able to generate clear and actionable outputs. Ultimately, the fuzzy system was validated through comprehensive rule testing and overall model evaluation. Sensitivity analysis revealed that the implemented fuzzy inference system effectively captured the logical relationships between inputs and outputs. The results of the modeling and sensitivity analysis indicated that the “consumption difference” variable (stemming from measurement and calculation errors) exhibits the highest sensitivity in reducing non-technical losses; thus, addressing this factor can significantly enhance the operational performance indicators of the network.

Keywords: Fuzzy Inference, Electric Energy, Consumption Difference, Non-Technical losses, Consumption Damage, West Azerbaijan Power Distribution Company.

Date of sending: 2024/06/01
Acceptance date: 2025/08/10

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