MODERNIZATION OF THE 220 AND 110 kV OUTDOOR SWITCHGEAR OF THE "YUKSAK" SUBSTATION THROUGH THE REPLACEMENT OF OUTDATED EQUIPMENT WITH GIS AND THE INTRODUCTION OF DIGITAL RPA DEVICES

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Abstract

The article examines the modernization of the "Yuksak" 220/110/35/10/6 kV substation by replacing outdated 220 and 110 kV outdoor switchgear with gas-insulated switchgear. The necessity of transition from oil circuit breakers and traditional control schemes to modern GIS and digital relay protection and automation devices is substantiated. It is shown that the proposed modernization makes it possible to increase the reliability of power supply, reduce the scope of operational maintenance, decrease the occupied area, improve the level of electrical safety, and ensure the integration of the substation into a digital control system.

Keywords: substation, outdoor switchgear, GIS, gas-insulated equipment, relay protection, automated process control system, digital substation, reliability, modernization, electrical safety.

Main text

In the modern conditions of development of the electric power industry of the Republic of Uzbekistan, improving the reliability and efficiency of high-voltage substations is becoming particularly relevant. Substations of the 220 and 110 kV voltage classes perform a key function in the transmission and distribution of electrical energy, supplying industrial enterprises, urban infrastructure facilities, social institutions, and the residential sector. At the same time, a significant part of the

operating high-voltage equipment has been in service for a long period and shows signs of physical and moral wear.

The “Yuksak” 220/110/35/10/6 kV substation is an important power node that provides reception, transformation, and distribution of electricity in Tashkent. On the 220 and 110 kV sides, the existing scheme uses outdoor switchgear, including oil circuit breakers, disconnectors, instrument transformers, surge arresters, and traditional relay protection and automation devices. Despite the fact that the equipment remains operational, it does not fully meet modern requirements for reliability, safety, environmental performance, and digitalization.

The main problems of the existing outdoor switchgear are high dependence on climatic factors, a large occupied area, complexity of technical maintenance, the presence of oil-filled switching equipment, increased fire and environmental risks, and limited possibilities for integration into modern automated control systems. Oil circuit breakers require regular monitoring of oil condition, repair of operating mechanisms, inspection of insulation, and checking of contact connections. In addition, during long-term operation, the probability of failures during the interruption of short-circuit currents increases, which may lead to emergency shutdowns and disruption of consumer power supply.

One of the most effective directions of modernization is the replacement of outdoor switchgear with gas-insulated switchgear. GIS is characterized by a compact modular design, high dielectric strength, hermetic sealing, resistance to external environmental influences, and increased maintenance safety. Unlike outdoor switchgear, where live parts are located in an open yard, in GIS the main elements are placed inside grounded metal enclosures filled with SF_6 gas. This reduces the probability of insulation flashovers, corrosion of live parts, and failures caused by contamination or moisture exposure.

For the “Yuksak” substation, the transition to GIS is of particular importance because the facility is located in an urban area, where rational use of territory is an important design factor. The application of GIS allows the area of the switchgear to be significantly reduced, simplifies the equipment layout, and decreases the scope of maintenance work. In addition, the enclosed design of the equipment increases the safety of operational personnel, since accidental contact with live parts is excluded and the need to perform work in high-risk zones is reduced.

Table 1. Technical and operational comparison of outdoor switchgear and GIS

Indicator	220/110 kV outdoor switchgear	220/110 kV GIS	Modernization result
Occupied area	Requires a significant open area and large insulation clearances.	Has a compact modular arrangement.	The equipment installation area is substantially reduced.
Influence of the external environment	Equipment is exposed to dust, precipitation, humidity, and contamination.	The hermetic design reduces the influence of climatic factors.	The stability of insulation and contacts is increased.
Switching devices	Outdated oil circuit breakers are used.	Gas-insulated circuit breakers are used.	Fire and operational risks are reduced.
Technical maintenance	Regular inspections, mechanism repairs, and oil monitoring are required.	The scope of scheduled maintenance is significantly smaller.	Maintenance labor intensity is reduced.
RPA and control	Traditional or partially digital system.	Microprocessor-based RPA terminals integrated into the APCS.	Selectivity, operating speed, and diagnostic capabilities are improved.

Environmental safety	There is a risk of oil leakage and soil contamination.	Large volumes of oil are absent; SF_6 control is required.	Environmental risks are reduced.

An important element of modernization is the introduction of digital relay protection and automation devices. Traditional electromechanical and outdated electronic relays have limited capabilities for diagnostics, registration of emergency events, and data exchange. Modern microprocessor-based RPA terminals make it possible to implement the functions of distance protection of lines, differential protection of transformers and busbars, overcurrent protection, automatic reclosing, automatic transfer switching, arc protection, and emergency automation.

The integration of RPA into the automated process control system ensures the transition from local control to centralized monitoring of equipment condition. In this case, data on the positions of circuit breakers and disconnectors, current and voltage parameters, protection operation, and emergency events can be transmitted to the APCS server and to the dispatching level. The use of digital protocols, including IEC 61850, creates the basis for the formation of an intelligent substation in which protection, control, measurement, and diagnostics function within a unified information environment.

The technical effect of modernization is expressed in increased power supply reliability, reduced probability of emergency outages, shorter recovery time after faults, and longer service life of equipment. The hermetic design of GIS reduces the influence of external factors, while microprocessor-based RPA terminals provide high selectivity and fast tripping of damaged network sections. This is especially important for 220/110 kV substations, where the disturbance of one connection may affect the power supply of a significant group of consumers.

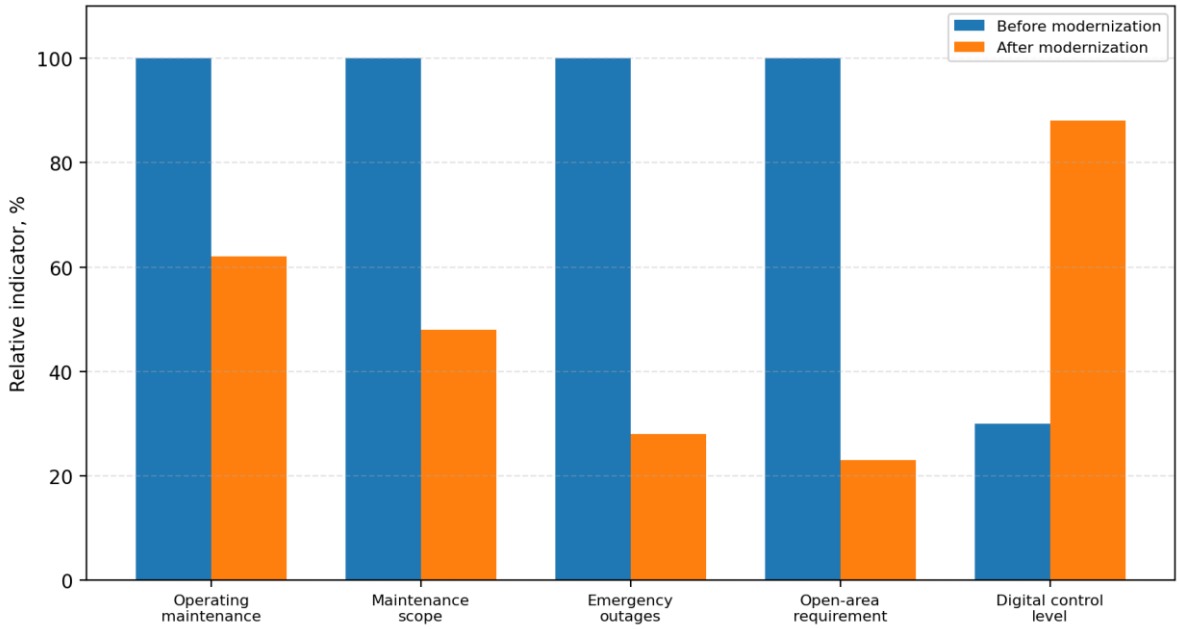


Figure 1. Relative change in technical and operational indicators after modernization of the "Yuksak" substation

The figure shows that during the transition from outdoor switchgear to GIS and the introduction of digital RPA, operating costs, the scope of technical maintenance, the probability of emergency outages, and the need for open territory decrease. At the same time, the level of digital control increases because the equipment becomes compatible with the APCS, monitoring systems, and remote diagnostics. In the thesis, the data are presented in relative indicators without specifying cost parameters, which makes it possible to focus on the engineering efficiency of modernization.

The environmental aspect is also an important advantage of the transition to GIS. Replacing oil circuit breakers reduces the risk of oil spills, soil contamination, and the formation of hazardous operational waste. The enclosed design of the equipment reduces noise impact and improves sanitary and hygienic operating conditions. At the same time, the use of gas insulation requires strict control of tightness and compliance with maintenance regulations, which must be provided for in design and operational solutions.

Thus, the modernization of the 220 and 110 kV outdoor switchgear of the “Yuksak” substation through the replacement of outdated equipment with GIS and the introduction of digital RPA devices is an integrated engineering solution aimed at raising the technical level of the facility. This approach combines the tasks of reliability, safety, energy efficiency, environmental performance, and digitalization, which corresponds to the modern requirements for the development of electric power infrastructure.

Conclusion

The conducted analysis shows that the existing 220 and 110 kV outdoor switchgear equipment of the “Yuksak” substation has significant physical and moral wear, which creates operational, economic, and environmental risks. Replacing outdoor switchgear with GIS makes it possible to increase the reliability of the substation, reduce the occupied area, decrease the scope of technical maintenance, and ensure a higher level of electrical safety. The introduction of digital RPA devices and their integration into the APCS form the basis for the transition to a modern digital substation. Therefore, the modernization of the “Yuksak” substation is technically justified, practically significant, and aimed at improving the stability of power supply in the power system of the Republic of Uzbekistan.

References

1. Law of the Republic of Uzbekistan No. ZRU-940 dated 07.08.2024 “On Energy Saving, Its Rational Use and Improving Energy Efficiency”.
2. Rules for Electrical Installations. 7th edition.
3. GOST 1516.3–96. AC electrical equipment for voltages from 1 to 750 kV. Requirements for dielectric strength of insulation.
4. IEC 62271-203:2022. High-voltage switchgear and controlgear — AC gas-insulated metal-enclosed switchgear for rated voltages above 52 kV.

5. IEC 61850. Communication networks and systems for power utility automation.
6. IEEE Std 80-2013. IEEE Guide for Safety in AC Substation Grounding.
7. Koch H. J. Gas Insulated Substations. Wiley-IEEE Press, 2021.
8. Siemens Energy. SIPROTEC 5 Protection, Automation and Monitoring: Application Manual.
9. NR Electric Co., Ltd. PCS Series Protection and Control Devices: Technical Manual.
10. Shandong Taikai High Voltage Switchgear Co., Ltd. ZF10 Series Gas-Insulated Switchgear: Technical Catalogue.