Development of a training complex of elements of power systems and metering of electric power with application of VR technologies

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Abstract. The paper describes the results of simulation of virtual power equipment of a substation and an electric power metering system for the purpose of training and practicing the actions of personnel during scheduled switching and emergency situations. An experimental model is presented that demonstrates the basic functionality of the simulator, which allows for rapid switching on a virtual substation model. The virtual model will help the trained operational personnel gain operational experience, as well as eliminate the possibility of electric shock and equipment failure. Due to the flexible functionality of the program that builds the project, it is possible to implement additional blocks of the simulator, having previously tested the innovation separately from the main project. This feature guarantees compatibility of new versions of the project with the old installed versions. It also allows the client to update the product without reinstalling the program. The model was created in the Unreal Engine 4 program. This product allows you to create projects for Windows, Lunix, and Mac OS operating systems. Unreal Engine 4 is compatible with the virtual reality system. Due to compatibility, it is possible to create interactive projects, in particular, an interactive project in the field of energy.

1. Introduction

According to the statistics of JSC “SO UES” for 2018, and the results of the investigations into the causes of accidents in electric grid equipment in the UES of Russia, 16% are due to erroneous actions of personnel, and in the electric grid sector of Russian Railways. The share of erroneous actions of operational personnel accounts for 6% of accidents.

The main violations are the lack of verification of removal of portable grounding or disconnection of grounding knives after completion of work, the lack of verification of compliance of dispatch names of the required switching equipment.

In this regard, we find relevant the issues of the use of simulators based on virtual reality systems for educating students, as well as the training and retraining of personnel of energy enterprises, which allow you to work out the actions of personnel during switching at the commissioning of substation equipment for repair and equipment inspections, its repair and replacement.

2. Development of the simulator

The advantage of using virtual reality systems (VR) in the electric power industry is the ability to create a virtual environment for specific technical situations. A virtual substation is not only a detailed
simulator with the ability to conduct training without the need for access to real equipment but also a tool for testing knowledge. The power equipment of the 110/10 kV substation was chosen as the object under study to create a virtual switching simulator [1]. Figure 1 shows the type of outdoor switchgear-110 kV.

![Figure 1. 110 kV outdoor switchgear.](image)

In this simulator, it is possible to conduct switching simulations for putting into repair and putting into operation power and measuring transformers, power switches, disconnectors, power lines (figure 2).

![Figure 2. Menu of operations with a linear disconnector.](image)

Possible emergency situations are modeled: emergency shutdown of the transformer due to breakdown of insulation, disconnection of the transformer under the condition of the gas relay being triggered, failure of the disconnector due to damage to the mechanical part, disconnection of the line due to a short circuit, etc. When working with the simulator, the operator has the ability to perform the following actions: inspection of equipment, switching devices, installing grounding, hanging posters (figure 3).
If the operator performs erroneous actions, depending on the degree of criticality of the error, visualization of the consequences is provided with the possibility of correcting the situation or terminating the test task (figure 4).

In addition to modeling the power unit, we made it possible to simulate the work with electricity metering systems. The description of the electrical counters is given in [2]. The simulator allows you to perform the following actions: installing a meter, simulating actions that ensure the safety of work when installing and replacing an electric meter, connecting phases in a certain order using a device for determining phases [3]. It is possible to conduct meter inspections in the simulator in order to detect deformations, damage to the case, check electrical insulation, check the correct operation of the counting mechanism in the meter, confirm the absence of “self-propelled”, check the sensitivity threshold of the apparatus, etc. (figure 5).
Figure 5. VR-model of the electric meter.

It is also envisaged to practice the inspection and repair of the meter in case of the following possible malfunctions: core wear during long-term operation, mechanical damage to the device and its parts due to vibration, corrosion of metal parts of the device.

3. Conclusion
When training specialists in the field of "Power Engineering and Electrical Engineering", an important aspect of training is the implementation of a practice-oriented approach. If it is impossible to gain experience on the real equipment of an energy facility due to a lack of qualifications and potential danger to the student, there is a need for the use of virtual reality simulators, which allows you to work out the actions of personnel during planned switching and emergency situations, test the student’s knowledge and simulate various modes of energy equipment.

Acknowledgements
The research is funded by Russian Federation public contract № 0720-2020-0025 "Technique development and method analysis for ensuring power system object security and competitiveness based on the digital technologies”.

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