Organization of the operational management and change of the indicators for continuity of the electric power supply in Bulgaria

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***Abstract* — The paper presents the results of the reports and the analysis of the indicators for the quality of the electric power supply in the electric distribution networks of the EU and regions of the Republic of Bulgaria. The purpose of the study is to analyze and assess the impact of the Operational Management of Medium Voltage Network on the quality indicators of electric power supply in medium voltage distribution networks.**

Keywords— electric distribution network, quality of electric power supply, operational management, indicators, consumers, interruptions

I. INTRODUCTION

The proper functioning of the electric distribution network (EDN) requires that it be managed and operated in accordance with certain rules provided by the competent authorities. The rules for the management of the electric distribution networks also regulate the relations between the individual participants in the process of production and consumption of electricity - the EDN operator, the electric transmission system operator, the final suppliers, and the electric energy traders [1, 2, 3].

Each electric distribution company is obliged to form a plan for the development of the electric distribution network operated by it, which should include measures to improve the efficiency, modernize the existing network, rehabilitate the sites and facilities and improve their safety. This plan determines the need for the construction of new sites in the structure of EDN - substations, transformer stations and tie stations, and power lines with different voltage levels [4, 5].

The formation of an EDN development plan is a task related to the satisfaction of many contradictory requirements. The main requirements that are observed when planning the development of EDN are:

- construction of the network with minimal investment costs;
- realization of the lowest possible operational and technological costs for electric energy distribution;
- compliance with the conditions for the reliability of electric power supply;
- ensuring the safety of people operating and using the network;
- limiting the impact of EDN on other technical systems to acceptable levels;
- environmental protection.

The EDN development plan is accompanied by analyzes taking into account technical, economic, environmental, financial factors, as well as measures to reduce the technological costs of electric energy distribution.

The basis of the operational management is ORDINANCE № RD-16-57 of MEE. This ordinance regulates the conditions and the order under which the operational management of the electric energy system (EES) and the activity of the transmission system operator (TSO), the operators of each of the distribution network and the operational duty personnel from the electricity sites, and the electrical installations of the consumers. It is related to the dispatching and balancing of production, import, export, transmission, and distribution of electric energy, cold reserve, system, and ancillary services [6].

The operational management of the respective distribution network is performed by specialized dispatching units (SDU), defined in the regulations for the structure and activity of the respective distribution company. Distribution network operators shall be independent in terms of operational management from the other activities of the distribution companies.

The specialized dispatching units manage the network through a combination of two main approaches:

- through operational duty personnel in the substations;
- through operational and repair groups, which are assigned to the facilities of the EDN.

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The provision of operational management by specialized dispatching units is related to the collection and processing of information on loads and electrical diagrams, data on equipment and condition of facilities in the distribution network, as well as power plants connected to the respective distribution network.

According to the current normative documents [4], the duties of the operational staff include analysis of the disturbances in the normal operation of the distribution network and implementation of the necessary measures to increase safety during operation. If it is necessary to temporarily limit the consumption/production of electric energy, this is done after the order of the given territorial dispatch management in accordance with a pre-prepared program.

As a result of the operational management, the network is able to meet all the challenges related to the operation, as well as to react in the event of specific impacts of internal and external factors on the normal operation.

II. PRINCIPLES AND TECHNICAL SOLUTIONS IN EDN OPERATIONAL MANAGEMENT

The application of modern organizational measures leads to a change in the reactions in the event of an accident and, accordingly, to a change in the indicators for continuity of the electricity supply for the respective company.

Many of the organizational activities lead to a change in the way of work that has been practiced in the past:

- Search for a fault;
- Carrying out planned safety repairs/planned activities;
- Use of remotely controlled switching equipment - switches (reclosers) and power disconnectors;
- Use of SCADA system with elements of telemonitoring and telecontrol;
- Proper placement of operational and repair groups;
- Temporary operation in parallel of two power lines;
- Improving the settings of relay protection and automation (RPA).

All these measures are caused by the desire of EDC to improve the quality of customer service. To reduce the number and duration of disturbances in accidents and planned activities.

Complexly, all this activity leads to an increase in the quality of the voltage [7, 8], the quality of the power supply [9] and significantly reduces the disturbances in the EDN, and allows the consideration and thorough analysis of each individual aspect and its contributions to the improvement of the power supply.

Depending on the type of the EDN - cable or overhead power lines, the organizational measures to increase the reliability of the network and improve the quality indicators of the power supply are specific. With a change in the organization of the work of the teams (their number) and the available resources (switchgear), a reduction in the number and duration of power outages is realized.

Minimizing losses and ensuring maximum security of electric power supply is guaranteed by maintaining the normal state of the network - power lines. Maintaining the EDN in a state as close as possible to its design state is the main task of the operational staff. This applies to both overhead and cable power lines. The availability of up-to-date information about the resource of the network helps to make a correct assessment of its capabilities for power-flow distribution, in case of operational need.

The presence of a large share of overhead power lines in the network is a prerequisite for a large number of interruptions in case of force majeure (mainly meteorological) and hence higher values of the SAIFI and SAIDI indicators. Unfortunately, the Republic of Bulgaria is not excellent in this activity, and accordingly, the operational management of the operation has a serious impact on these indicators.

Cable power lines have high power security and line protection. Ultimately, both types of networks have their advantages and disadvantages. Therefore, the application of any of them should not be an end in itself but should be carried out as planned and after analysis of its benefits.

Making fuller use of the capabilities of the available switching equipment for operational switching leads to a sharp reduction in switching time and increased operational safety. The correct choice of the place for their installation leads to multiple savings of working hours of the employees, as well as machine hours of the used equipment for reaching and performing the switching manually.

The use of telemechanics (if any) by the operating staff to perform switching in the EDN has a strong impact on minimizing the number of affected customers and the duration of the interruption. Switching them minimizes the number of customers and the time they are without power. In addition to the means for telemechanics, specialized SCADA software is applied for the operational management of EDN, which leads to the unification of the work process of the dispatchers - one software, one computer.

The operational control of the grounding mode of the power transformers in the substations increases the quality of the power supply. The mode of operation of the power transformer, isolated or grounded by an arc-suppression coil (L), active resistance (R), or combined (L + R), depends on the type of network. In the case of combined earthing L+R - the occurrence of two-phase and three-phase short circuit leads to disconnection of the power line from time-delayed overcurrent protection, instantaneous overcurrent protection, or distance protection. In case of single-phase failure, if the short circuit does not disappear for 1s, the active resistance is connected to the ground circuit, which causes disconnection of the damaged line, followed by an attempt for an automatic reclosing (AR). In case of unsuccessful AR, sub-sequent activation of the active resistance is not allowed.

Principles for localization of faults in EDN are defined. If part of the network fails due to a short circuit, it is generally necessary to try switchings in order to determine the range and locate the fault. The purpose of these switching attempts is to identify and disconnect damaged sections of the network as quickly as possible. In case of the increased impact of the atmospheric activity, the type of actions taken depends on the operation of the automation systems and the type of network powered by the given substation. In case of repeated disconnections with successful ARs of a given power line

within a short period of time - the operation of it's AR is temporarily terminated. At the substations powering a mixed type of network, two (three) transformers are switched on and overhead and cable lines are separated between the separate transformers depending on the grounding mode.

When limiting the short circuit currents, their harmful impact on the insulation of the other power lines and the equipment installed on them is reduced.

The application of modern technical solutions such as an arc-suppression coil with an increase in the active current component (ACC) of a ground connection significantly increases the operational flexibility in network management. Operations personnel locate the fault without interrupting the power supply in compliance with the necessary safety requirements. The main advantage here is that consumers have power throughout this process. This minimizes downtime and the number of users affected.

Along with the implementation of technical measures, operational management can be improved through the use of organizational measures to increase the reliability of EDN and improve the quality indicators of the electric power supply.

The main organizational measure for improving operational management is the creation of operational instructions for work in a planned mode and in case of accidents.

The sequence of operational actions in different types of accidents that occur in different types of EDN is determined. This sequence includes the following steps:

- Sectioning of the fault;
- Localization of the fault;
- Elimination of the fault;
- Restoration of normal power supply to consumers.

Here, too, the basic principle of operation should be applied - minimizing the number and duration of interruptions in the power supply to consumers, and if necessary, introduce regulated consumption and production of electric energy.

Special instructions regulate how to act in the event of an increased accident or crisis. Special actions have been developed when working with the Crisis Staff, interacting with institutions, organizations, and fire departments [4].

All actions of the operational staff, both the superior and the executive, are related to the performance of manipulations under conditions of technical and organizational safety, as the health and life of the operational staff are of the highest priority.

III. Analysis of indicators with improved operational management

In order to analyze the impact of operational management on the indicators of continuity of electric power supply, a study was conducted to determine the impact of the above measures concerning the grounding regime of the transformers in a substation with increased exposure to external factors during two summer months July and August.

The study covers the impact on quality indicators calculated according to the EWRC methodology in a substation with mixed overhead and cable power lines.

For the purposes of the research, various circuit variants for the operation of the transformers and their grounding have been realized.

Option 1. The substation is powered by one transformer grounded through an active resistance.

Option 2. The substation is powered by two transformers

- **Transformer "A"** supplies the medium voltage network, which is predominantly constructed with cable lines (over 90% of the total length), and the transformer is grounded through active resistance.
- **Transformer "B"** supplies the medium voltage network, which is predominantly constructed with overhead power lines (over 90% of the total length), and the transformer is grounded through an arc-suppression coil.

In this substation, the magnitude of the capacitive currents does not allow the operation of the grounding of the transformer only with an arc-suppression reactor.

Fig. 1 presents the results for the number of interruptions per calendar month for the two schematic options. Examined around the clock, we see that the distribution of power lines on transformers and the application of an appropriate grounding mode of the transformer leads to a significant reduction in the number of interruptions.

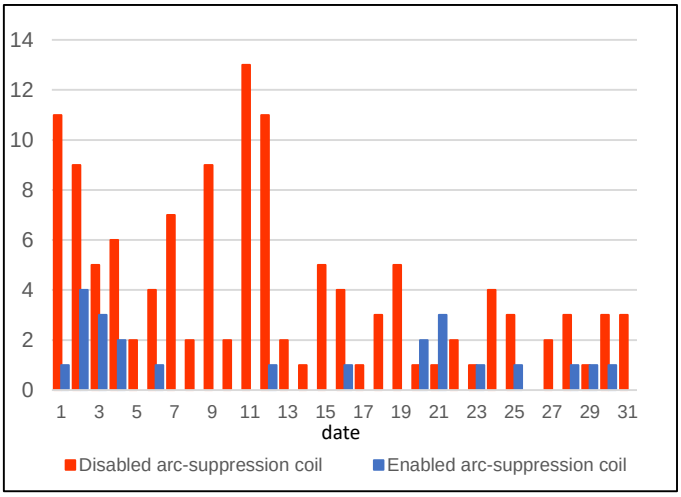

Fig. 1. Interruptions in a substation with mixed power lines

In reality, earth faults occur during the period under review, but the limitation of the fault current leads to the suspension of its impact and it does not cause an interruption.

The reasons for such transitional short circuits can be:

- trees (poor clearing);
- birds - single (like storks) or flocks of many birds (up to several thousand);
- bad weather conditions ;
- increased lightning activity.

Considering the results of the study, a realistic assessment can be made of the impact of the use of an arc-suppression coil on SAIFI/SAIDI in case of unplanned power supply interruptions of air and cable power lines during separate operation of transformers in distribution substations.

The influence of the number of transformers and the mode of their grounding on the indicators for continuity of the power supply is presented in Fig. 2 and Fig. 3.

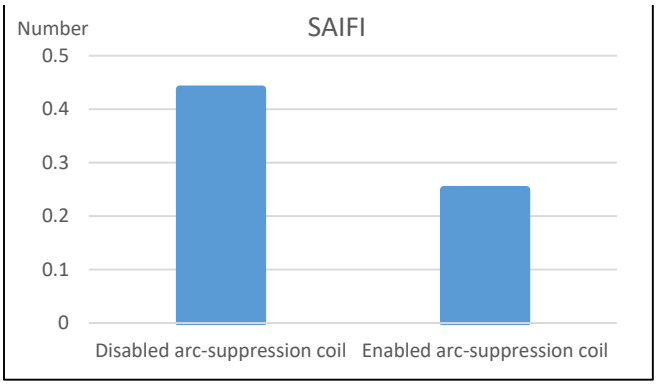

Fig. 2. Values of the SAIFI indicator

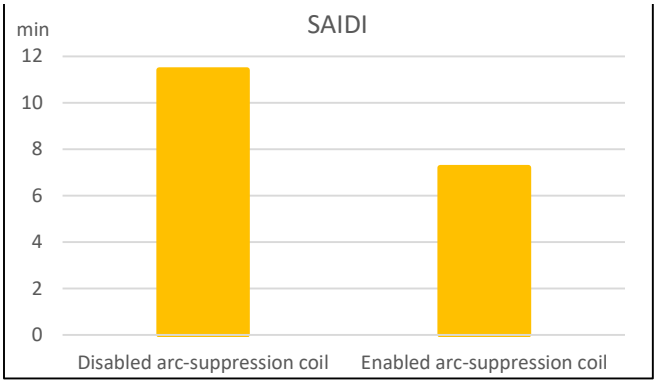

Fig. 3. Values of the SAIDI indicator

When a second transformer with an arc-suppression coil supplying all overhead power lines in the substation is connected, it can be seen that the number of shutdowns decreases sharply. It also reduces the duration of power supply interruptions for consumers. These measures lead to an increase in the quality of power supply and a decrease in the overall indicators SAIFI and SAIDI, by reducing the relative contribution of the specific substation in the summarized indicators of the company.

IV. Conclusion

The use of a combination of organizational and technical measures can significantly change the quality of power supply to customers.

The use of available resources in the network - two or more transformers in the substations, with different grounding mode increases the quality of power supply.

Using more staff for operational switching minimizes the time required to change the EDN configuration.

A preparedness plan needs to be prepared to deal with risks and scenarios in the event of a power crisis. They should address the roles and responsibilities of the competent authority, as well as procedures and measures in the event of a power crisis.

The creation of rules for management of EES and EDN leads to unification of the operational management and increase of the efficiency of the network.

The creation of new methods for operational management and the use of SCADA puts on a new higher efficient level of EDN use and hence high quality of services.

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