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REZUMAT

TEZĂ DE DOCTORAT

CREŞTEREA CALITĂŢII ENERGIEI ELECTRICE PRIN SISTEME DE AUTOMATIZARE A REŢELEI DE DISTRIBUŢIE

INCREASING THE QUALITY OF ELECTRICITY THROUGH DISTRIBUTION NETWORK AUTOMATION SYSTEMS

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Content

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Chapter 1.

Electricity quality and quality indicators

1.1. Introduction

The electricity sector has undergone substantial changes in recent decades, both due to changes in their organizational systems and due to the emergence of new systems for the production and use of electricity.

These changes include the emergence of renewable energy sources and storage systems, users using power electronics, automation and control systems, as well as changes in electricity distribution networks by creating micro-networks with decentralized management systems. The distribution operator must reduce the number of voltage disturbances, but also quantify them [1].

1.2. Quality indicators for electrical distribution networks

Continuity in the supply of consumers is determined by the operation of the entire energy system, which must cover the needs of the consumer and an appropriate response to the dynamic processes that occur when the system moves from one state to another. The continuity indicators of the power supply, defined in [13], are:

Average System Interrupt Frequency Index (SAIFI) calculated as the ratio of the total number of interrupted users in a year to each of the long-term interruptions and the total number of connected users. in the analyzed system. "

$$SAIFI = \frac{\sum N_s}{N_t}, \tag{1.1}$$

where Ns is "the number of users interrupted over 3 minutes in the outage and n the total number of outages", Nt - "the total number of users served".

"System Average Interruption Duration Index (SAIDI) at one year as the ratio of the total duration of interruptions in all discontinued users to the total number of users connected to the analyzed system."

$$SAIDI = \frac{\sum (N_s \cdot D_s)}{N_t}, \tag{1.2}$$

where Ns is "the number of users interrupted over 3 minutes in the interruption s, n - the total number of interruptions", Nt - "the total number of users served", Ds – "the duration of the interruption of users (minutes) at the interruption s".

Long-term outages are characterized by a duration of more than 3 minutes in which the voltage has zero value (figure 1.1) [14].

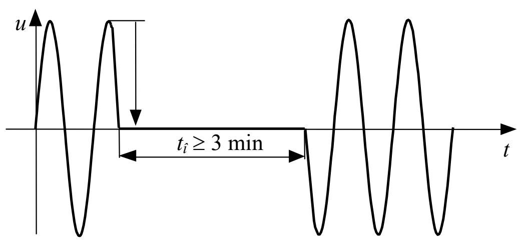

Fig. 1.1. Întrerupere de lungă durată.

1.3. Quality indicators for electricity transmission networks

In electrical transmission networks, the interruptions are characterized by the time interval in which in a node of the transmission system (from the user or from the interface with the distribution system) the power supply is interrupted. Interruptions are characterized by their frequency, duration, and size of the interrupted load.

1.4. Determination of power continuity indicators

The number of interrupted users (with time interval> 3 min) - Ns - at each of the interruptions made can be determined based on the analysis of each feeder and interface elements between different voltage systems.

The number of interrupted users and the duration of their interruptions could be determined using SCADA systems or other monitoring equipment.

1.5. Effects of power outages

At the level of power supply, the fundamental principle is to reduce the number and amplitude of failures in the distribution system. This can be done by preventing accidents and eliminating them.

The distribution system operator must take steps to ensure an adequate level of continuity of supply. Analyzing the impact of network failures on users' power systems requires equipment calculation and modeling methods to quantitatively analyze the damage caused by events in electrical systems.

1.6. Means of improving continuity of supply

Obtaining information on long-term outages and determining quality indicators for distribution networks requires the availability of data on the duration of the event, as well as the number of users affected.

SCADA systems can provide the duration of outages and can provide the necessary data for the evaluation of quality indicators, corresponding to the level of responsibility of the network operator. In principle, the system tries to include equipment for voltage monitoring and equipment for transmitting information, which tries to attach a time label and user data.

Chapter 2.
Monitoring the quality of electricity and methods to reduce long-term outages

2.1. Monitoring the quality of electricity

Intelligent electrical networks represent the next level of development of electrical networks as a result of the technological progress of electrical equipment, the development of computing techniques specific to electrical networks, but also of telecommunications systems.

New power grids are distinguished by a high degree of intelligence, due to the large number of applications that are implemented at various levels of the power grid [15 - 19].

Technological developments such as "microgrids" or "distributed resources" are helping to reduce supply voltage fluctuations.

Monitoring the quality of electricity requires analyzing the phenomena that occur in the operation of electricity networks so that the technical solutions adopted to compensate for certain disturbances do not cause the increase of other types of interference.

2.1.1. Processing of acquired data

Data purchased from TT voltage and TC current transducers are transmitted to an intelligent electronic device (IED) for processing for various purposes (relays, measuring devices, meters, controllers) connected to the automation system of the SAS distribution station (Substation Automation System) and which ensures the processing of data and the extraction of information necessary for the operation of the system

The functions that can be implemented in a smart metering system (Smart Metering) correspond to the logical nodes implemented in the IED [26].

2.1.2. Evaluation of electricity

Smart metering system:

- provides the conditions for a secure exchange of information between network operators.
- allows a two-way communication between the energy supplier and the energy user
- offers the possibility to read from a distance the recorded data in order to be known both by the measuring operator, the energy supplier and by the electricity market operator;
- ensures the possibility to change the electricity tariff according to the prices on the electricity market [27];

2.1.3. Advanced measurement infrastructure (AMI)

AMI is an infrastructure that allows two-way communications between the energy management system and the meters in the system, and it is also possible to connect other internal devices [25].

2.1.4. Data management

The role of MDM (Meter Data Management) is to use and manage the data obtained from AMI smart metering, to provide the necessary data to the measurement operators. The MDM system is connected to the market systems, to the SCADA system, the interrupt management system, allows the exchange of data between companies, allows the management of user relations.

2.1.5. Use of data to evaluate events

The knowledge of the variation in time of the powers absorbed by the user (receivers) allows both him and the energy supplier to establish the energy behavior of the user and to estimate the evolution of the absorbed powers, thus being possible to adopt measures to avoid events. For example, knowing the real-time evolution of the absorbed power can provide the information needed to approach a peak consumption and, if possible and necessary, limit the absorbed power to limit the peak power.

2.2. Methods of reducing long-term interruptions

Increasing the continuity of the power supply requires interventions in the power supply scheme in the user's network or in the network of the distribution operator.

The quality of electricity provided by the distribution operator, corresponding to a normal operation of the energy system, may not meet the requirements of users. The current technical solutions allow to obtain quality indicators of the energy supplied at the parameters necessary for the users.

Network reconfiguration involves continuous monitoring of system status and power quality so that it is only compromised over short periods of time.

Changing the configuration of the distribution network, including the operation of a partial scheme can be economically beneficial by reducing losses in low load regimes, providing power to users in case of faults and the possibility of performing on-line maintenance operations.

Network reconfiguration can be performed prior to preventive maintenance or to allow massive integration of distributed sources without affecting permissible voltage levels.

Chapter 3.

Analysis of the operational management of urban electricity networks to improve the quality of electricity

3.1. Introduction

The current trends of knowledge as accurate as possible and in the shortest possible time of the general state, respectively of the events produced in an electrical network, imply the use of the latest technologies in the field of informatics and telecommunications.

The operational management of the energy system is a necessity, and the main objective is to increase continuity in the supply of end users. The activity of dispatchers is vital for improving the continuity of electricity supply to users.

3.2. DED operational management

SEN operates in an interconnected regime with the electricity systems of other countries, according to the agreements and conventions signed with the respective countries, or in isolation, with self-regulation.

Dispatcher driving allows [40]:

a) safe operation of the energy system;

b) the balance between production and consumption;

c) control of cross-border trade;

d) coordination of the operating regimes and of the maneuvers in the electrical installations from SEN;

e) performing the necessary maneuvers;

f) use of available sources.

3.3. Use of centralized dispatching using the SCADA system

At the level of Romania, there are a series of distribution companies whose development was carried out in step with the development of the Romanian energy sector. The analyzed case study is carried out on a network area in Argeș County, distribution companies serving over 1 million users connected to 110 kV, medium voltage and low voltage.

3.4. Flexible allocation of dispatching areas

The flexible allocation of dispatching areas has managed to balance the volume of activity of each dispatcher per job, so that, regardless of the time of day, the activity of the dispatcher is approximately equal. SCADA Mikrodispecink is a software developed by CEZ - Czech Republic, being a modern control system that promotes an economic management of operations, a system of confidence, safety and flexibility in operation, which leads to the reduction of continuity indicators "SAIFI / SAIDI", as well as reducing operating costs.

3.5. Acquisition and use of data

The inspection of the processes in the power supply installations is made on the basis of information on the quantities in the electrical circuits, on the condition of the equipment in the system as well as on the basis of the information obtained after processing the purchased data. The most important primary data are purchased from voltage and current measuring transformers or other systems for measuring these quantities.

The IED devices distributed in the station are connected to a data concentrator that provides the connection to the equipment in the station. Data transfer can be initiated from any end of the connection (smart devices can be connected to each other and to other devices through different means of communication).

3.5.1. The structure of an intelligent electronic device

The control of all processes in a power station and the control is based on the information transmitted from the transducers and sensors connected to the process level. A special role is played by voltage and electric current transducers which provide information on voltage level, electric current values and frequency, on the basis of which the transferred active, apparent and reactive powers, the distortion levels of the voltage curves and power supply, power factor values, energy transferred through the circuits in the power station, etc.

The data obtained through the process interfaces are transmitted to the control and protection blocks through various communication channels (optical cables or copper cables).

An IED is a piece of equipment that includes a microprocessor and related software, which allows the implementation of one or more functions regarding a certain aspect of a piece of equipment, for example bar control, SCADA interface system, microprocessor-based numerical relay, etc. The IED is a piece of equipment in which some of the functions of the power station automation system are implemented.

These devices allow the acquisition and initial processing of the acquired data, as well as the transfer of information to a higher hierarchical level [44].

3.5.2. Logical devices and logical nodes

The physical IED device that comprises the logical nodes is a device connected directly to the mains. The device is defined by its network address.

The logical node is a group called data and associated services that is logically linked to some functions of the power system.

The logical device is like an entity that represents a set of typical station functions. Each logical device (LD) consists of at least three logical nodes.

The LD logic device contains information generated and used by a group on specific domains of the application function, defined as LN logic nodes, and contains the following categories of information [46].

Chapter 4.

Improving the operation of electrical distribution networks to increase supply continuity

4.1. Performance regulations for the electricity distribution service

According to the performance standard for electricity distribution approved by order. 28/2007, but also to the present standard approved by ord. 11/2016, the distribution operator must ensure the security of electricity supply to the consumers served [47-48]. The Distribution Operator (OD) must take all necessary measures to reduce the interruption period. Planned outages should also be scheduled, as far as possible, in periods that affect the end user as little as possible.

The regulations in force oblige the distribution operators to grant compensations directly to the users for the non-observance of the imposed performance indicators, these compensations not being considered justifying costs of OD and are not taken into account by ANRE when establishing the electricity distribution tariffs.

For JT networks the number of long-term unplanned outages affecting a place of consumption / production 1 Jan. 2019 - 31 december 2020, under normal weather conditions, in one year must not exceed:

- in the urban environment - 12 unplanned interruptions;
- in rural areas - 24 unplanned outages;

during January 1. 2021- 31 december 2022:

- in the urban environment - 8 unplanned interruptions;
- in rural areas - 16 unplanned outages;

and starting Jan. 1. 2023 must be less than 8 interruptions.

As of July 1, 2016, OD automatically grants compensation according to Table 4.1 without the need for a request from users whose consumption and / or production sites are connected to RED at IT, MT level for non-compliance with performance indicators and at JT for non-compliance with the performance indicators regarding the technical quality of the electricity, as well as the commercial quality of the distribution service.

Table 4.1. Compensation granted by OD to users for non-compliance with continuity indicators in the power supply

Nr. crt.	**Service**	**The maximum term established in the standard for the performance of the service**	**Compensation awarded Place of consumption / production and place of consumption and production**
1	Restore power after an unplanned outage	From the date of entry into force of the standard until December 31, 2018; 8 hours - urban environment, in normal weather conditions; 18 hours - rural environment, in normal weather conditions; 48 hours - in special weather conditions. As of January 1, 2019: 6 hours - urban environment, in normal weather conditions; 4 hours - county seat municipalities, in normal weather conditions; 12 hours - rural environment, in normal weather conditions; 48 hours - in special weather conditions.	300 RON / exceeding 110kV 200 RON / overrun at MT 30 RON / overrun at JT
2	Restore power after a scheduled outage	8 hours - regardless of area	300 RON / exceeding 110kV 200 RON / overrun at MT 30 RON / overrun at JT
3	Number of unplanned long outages affecting a place of consumption and / or production connected	Interval January 1, 2019 - December 31, 2020: 12 interruptions - urban environment; 24 interruptions - rural environment;	30 RON / overrun at JT

	to JT electrical networks	Interval January 1, 2021 - December 31, 2022: 8 interruptions - urban environment; 16 interruptions - rural environment; As of January 1, 2023: 8 interruptions - regardless of area.	
4	Number of long unplanned outages affecting a place of consumption and / or production connected to IT or MV power grids	As of January 1, 2019: 3 interruptions - regardless of area.	300 RON / exceeding 110kV 200 RON / overrun at MT
5	Number of planned long outages	4 interruptions - urban environment; 8 interruptions - rural environment.	300RON / exceeding 110kV 200RON / exceeding MT 30 RON / overrun at JT

4.2. Identify and isolate the faulty network area

In order to correctly reflect the continuity of supply, but also the quality of the distributed electricity, the performance indicators require a strict monitoring of all interruptions, regardless of their character (planned / unplanned interruption), their duration, causes leading to interruption, but also the number of consumers affected and the power cut off.

The automation of medium voltage power lines aims to increase consumer safety, improve RED performance indicators and increase the quality of electricity.

Distribution automation consists of the installation of specialized equipment with the possibility of remote control (SCADA). By installing this specialized equipment (automatic reclosers), the 20 kV OHL is divided into several network areas and with a programmable logic controller it communicates via GPRS with each recloser.

If a fault occurs in any of the network areas of the OHL (fault detected by the reclosers' own protections), it will be isolated by the reclosers, and the logic controller will restore the power supply to consumers from the second source, of the unaffected network area, which leads to increased power continuity.

Table 4.2 shows the calculated values regarding the “SAIDI” indicator in the period 2015-2019 for the network operator serving the Argeș area, and in figure 4.4 is the graphical representation from which a decrease of the interruption duration in the analyzed network can be observed [49- 50].

Table 4. 2. “SAIDI” indicator calculated for the analyzed operator (interval 2015-2019)

Continuity indicator	**OD the year 2015**	**OD the year 2016**	**OD the year 2017**	**OD the year 2018**	**OD the year 2019**
„SAIDI” pl. Urban (min./an)	67,05	70,4	68,06	71,98	75,93
„SAIDI” pl. Rural (min./an)	348,06	301,38	293,72	258,53	285,02
„SAIDI” nepl. Urban (min./an)	186,72	159,73	143,53	132,05	106,2
„SAIDI” nepl. Rural (min./an)	554,69	468,85	429,3	373,62	284,46

The unplanned “SAIFI” has average values at country level around 3 [in / year], but well above the average value of about 1 - 2 in / year in advanced European countries, as can be seen in Figure 4.7 and Figure 4.8. The values of "SAIFI" planned interruptions are in the average value of about 0.1 - 1 in / year in the advanced European countries (figure 4.9 and figure 4.10). In 2018, the overall values for "SAIFI" planned interruptions were 0.21 in / year, representing the minimum value.

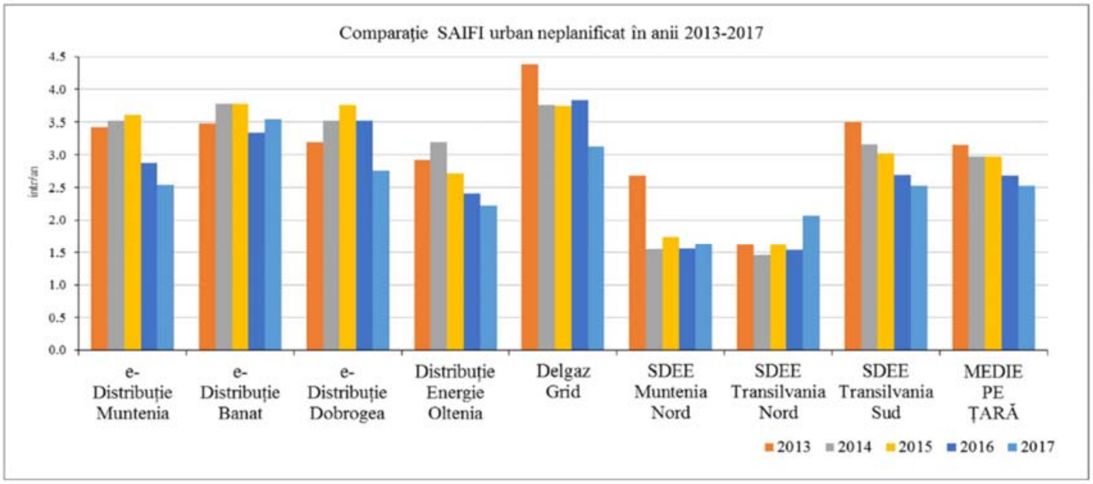

Figure 4.7. Unplanned urban "SAIFI" at the level of Romanian electricity distribution companies, in the period 2013-2017

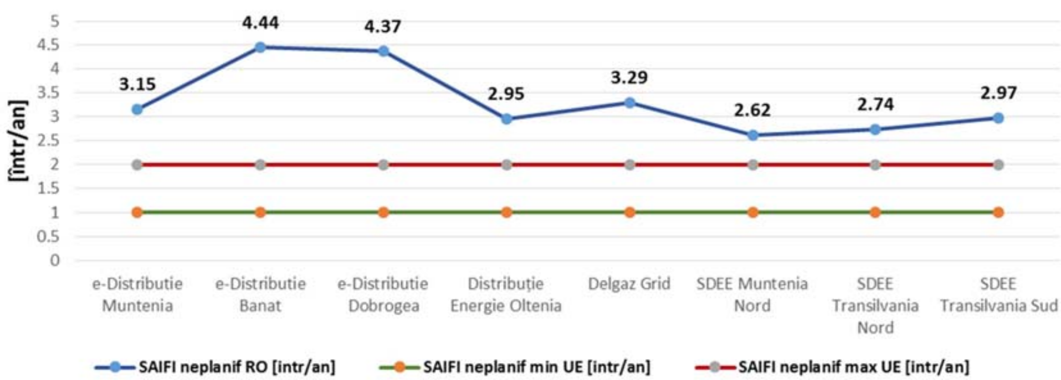

Figure 4.8. Unplanned urban "SAIFI" at the level of electricity distribution companies in Romania, in 2018

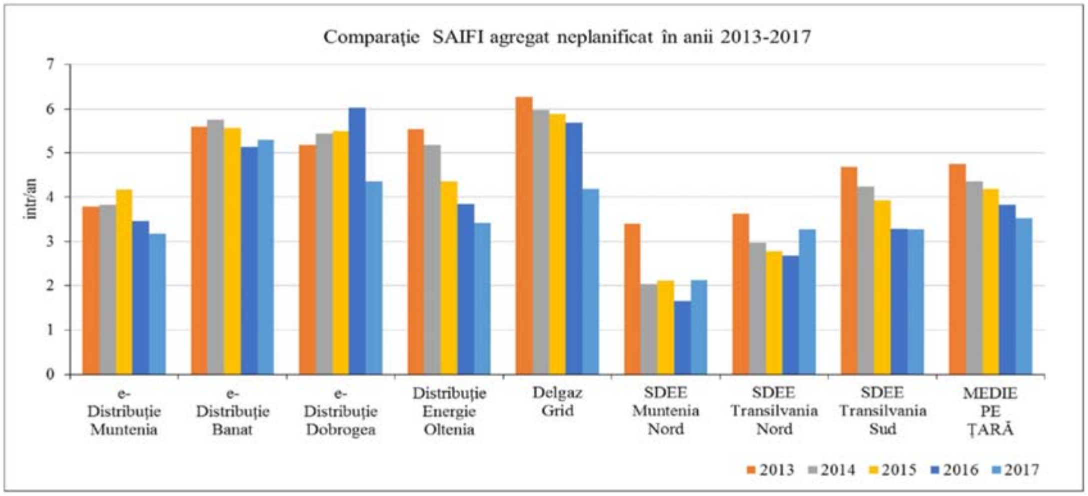

Figure 4.9. "SAIFI" aggregate at the level of electricity distribution companies, in the period 2013-2017

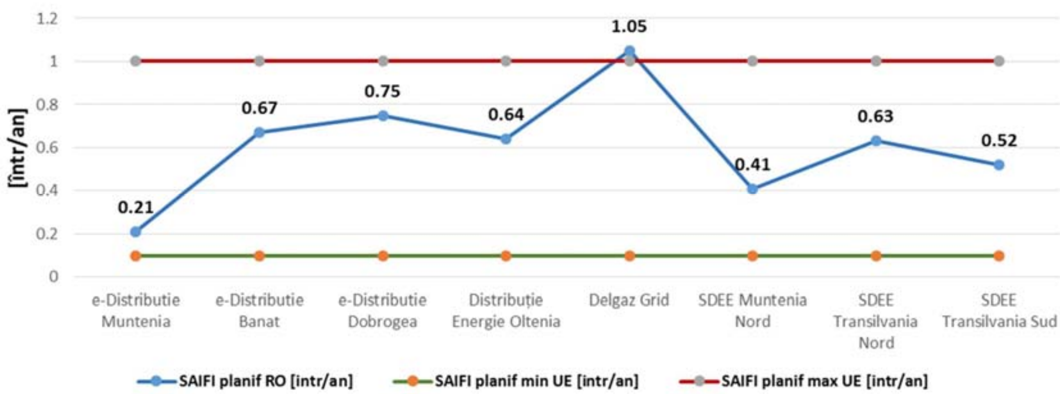

Figure 4.10. "SAIFI" aggregate at the level of electricity distribution companies, in 2018

The unplanned urban SAIFI was in 2018, as an average value per country, of 2.4 in / year. This may be due to the increase in consumption in Bucharest, as well as the infrastructure works carried out, the aging of the electricity networks, the meteorological phenomena that affect the overhead power lines.

The analyzed medium voltage network (LEA 20kV (A) - (B)) proposed for equipment with the monitoring and control system is supplied from PA 20kV (A), as a basic source, with the possibility of looping with: LEA 20 kV (D) - (B) and 20 kV LEA (A) - (C) [51].

The chosen 20kV LEA for which the quality indicators "SAIDI" and "SAIFI" were monitored and recorded has a length of approximately 60km and an Al-Ol conductor of 50/8 mm2 and supplies 4558 users.

The variation of the number of interruptions on the analyzed network, from Argeș county, is illustrated in figure 4.11. As can be seen, there has been a 50% reduction in the number of outages in the last year compared to the initial values. The variation of the "SAIFI" indicator is illustrated in figure 4.12

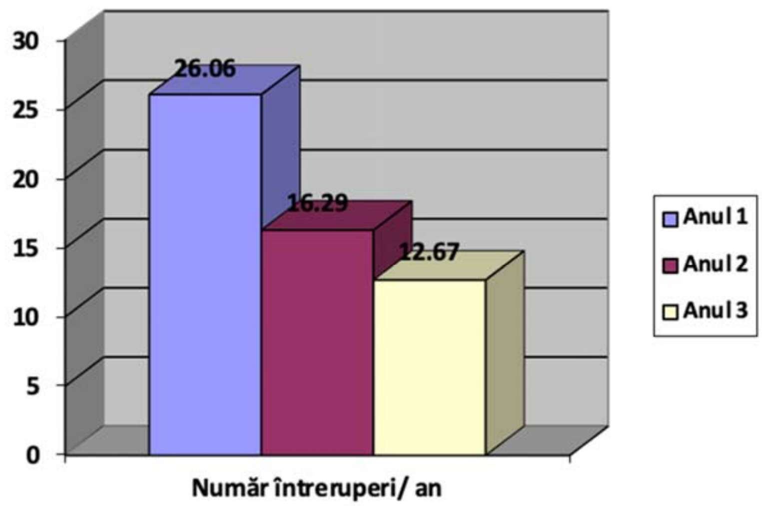

Figure 4.11. The variation of the number of interruptions on the 20kV OHL analyzed.

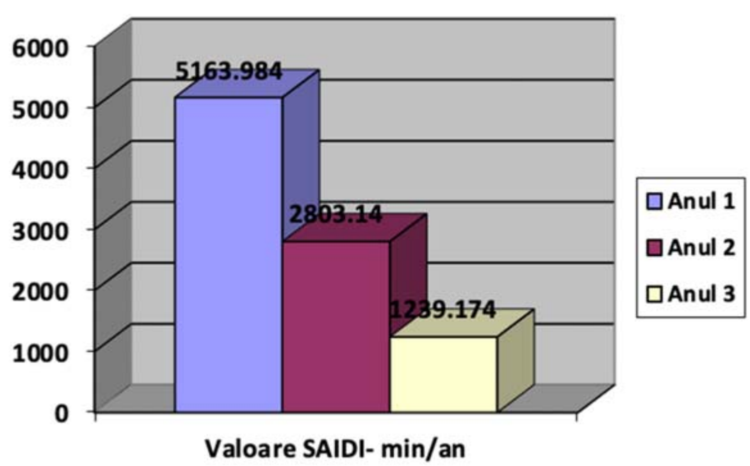

Figure 4.12. The "SAIDI" variation on the 20kV LEA analyzed

The positive results presented in figures 4.11 and 4.12, regarding the decrease of the interruption duration and of the interruption frequency for the analyzed 20kV LEA, in the 3 years studied, are due to:

- replacement of the connecting clamps at the level of the cords in the weak points;
- deforestation in areas with vegetation;
- technical revisions to switching equipment;
- partial replacement of the insulation;
- installation of new remote-controlled equipment;
- climatic factors (which differ annually and cannot be influenced);

On the existing LEA MT , in the places indicated on the single-wire diagram in figure 4.13, 8 remote-controlled reclosers will be installed. This led to the appearance of 7 sections of OHL shown in Figure 4.13, each area being bordered both upstream and downstream by an automatic recloser.

Reclosers are switching devices used in medium voltage overhead lines and stations to avoid longer network interruptions in the event of temporary failures. Like switches, they are capable of switching rated and fault currents.

The choice of the LEA MT in which the automation is to be carried out was based on the following criteria:

- the contribution of the "SAIDI" index;
- large number of consumers;
- LEA MT length;
- hard to reach area for electricians.

Therefore, the following equipment will be installed on the network:

- 1 self-healing controller at the dispatcher ("Self Healing Controller");
- 1 compact RTU in the 20kV PA substation (A);
- 8 Launchers together with their controllers;

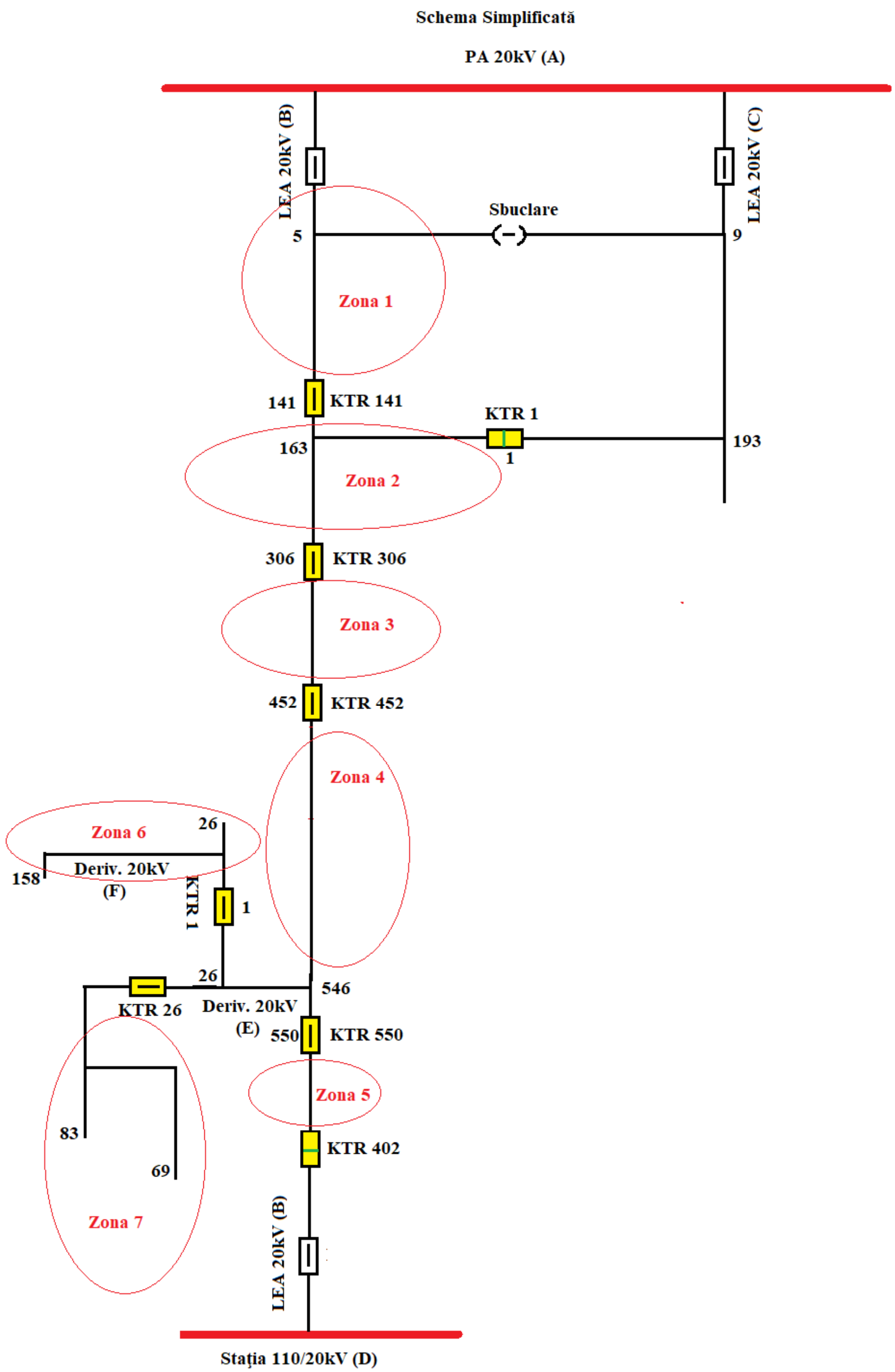

Figure 4.13. Single-wire scheme of the network analyzed with network areas

The programmable logic controller is the field remote control unit designed to automate processes that can control complex sequences of equipment management, which allows remote maintenance, remote diagnostics and remote parameterization.

Programmable logic equipment or programmable logic controllers are equipment designed for automatic process control.

The structure of an automated process with the help of a programmable logic controller can be synthesized by the block diagram shown in figure 4.14, the use of programmed logic being the qualitatively superior way of making the control equipment.

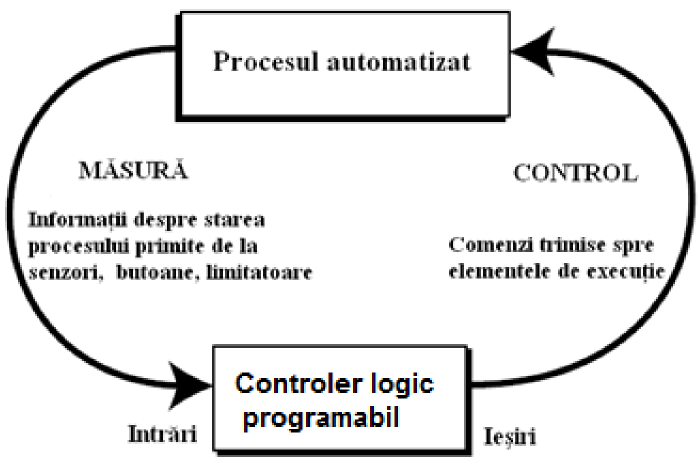

Figure 4.14. Automated block-process diagram using a programmable logic controller.

Because communication between the new reconnection controller and the self-healing controller will be via GPRS, the restore time may be up to 30 seconds, mainly depending on GPRS communication delays.

The self-healing concept ("Self Healing" automation) of the network includes 3 stages:

- in the first stage the protection will initiate the trigger. For this reason, the set of adjustments and coordination of protections will be designed to operate the lock next to the defective area. The recloser controller will have the specific protection functions available and activated.

- the second stage is the separation of the fault zone, being performed automatically after the ordered release. It will be monitored by the "Self Healing" controller in the dispatch center.

- the third stage is the energy supply of the healthy areas, monitored and controlled automatically by the controller associated with the central system "Self Healing".

The "Self Healing" controller provides the connection via the IEC 60870-5-104 protocol with the recloser controllers via a GPRS communication channel, the IEC 60870-5-104 interface for the connection with the 20kV PA (A) station and two IEC 60870-5- interfaces. 104 for connection to the redundant control center system (dispatching system).

Remote control of stations or power plants, using the IEC 60870 5-104 standard, allows the user to control separate locations at great distances from the centralized control room (dispatcher), optimizing the use of resources for that task. The definition of standardized remote control protocols makes it possible to integrate automated systems from different vendors with the utility control center. This allows you to control the system without the need for protocol converters or adaptations.

The controller with the self-healing function in the dispatcher center is responsible for all the logic and automatic restoration of the MV network, therefore it needs:

- GPRS communication with installed lockers controllers;

- IEC 104 communication with 20kV PA (A);

- IEC 104 communication with the "SCADA" system in the dispatcher center.

It monitors all recloser reconnect controllers and RTUs installed in the 20kV PA (A) and initiates automatic restoration in the event of a trip using a recloser or switch in substation (A).

For all faults (defined trigger events), an automatic restore will be initiated in the case of automatic mode. The sequences will run automatically, controlled and monitored by the self-healing controller, and the command from the dispatcher center switches to maintenance mode (where automatic restoration will be disabled).

It was assumed that when a short circuit or grounding occurs on one of the sections of the network of the 7 proposed, the defect will be detected and eliminated by the own protections of the reclosers, and by means of a programmable logic element that interacts with each recloser. fault and power from two sources will be restored.

If the lockers had not been installed in the studied network, the defect would have led to the final tripping of the circuit breaker in the 20kV (A) PA station or in one of the 110 kV / MT stations (after performing the RAR cycles), causing all power to fail. elements connected to the 20kV OHL.

Principles of automation operation:

- Any other operating condition related to the equipment described in the normal diagram will lead to the blocking of the automation;

- The commissioning / commissioning of the automation will be done by order from the Dispatcher.

- There will be 2 groups of settings (set 1 and set 2), set 1 of settings will be active in all relays for normal operation;

- For reclosers that change their power supply from Source 1 (PA (A) cel. 20kV (B)), or Source 2 (PA (A) cel. 20kV (C)) to Source 3 (Station (D) cel. 20kV (B)), the automation will switch to set 2 and the return to set 1 will be done manually from the spot or from the Dispatch Office.

- After an operation, the automation will be blocked and the unlocking will be done from the Dispatcher. When commissioning, the automation will check the correctness of the operating diagram and the sets of adjustments and if they do not correspond to the initial situation, it will give a message that will explicitly signal the inconsistency found.

Due to the large number of closures and the fact that we cannot increase the operating time of the protections in the source cell, non-selective tripping of the protections may occur.

To correct these inconveniences, the logic will reconnect the reclosers closest to the source, then refuel the areas with the possibility of power supply (the order of non-selective connections will be from the sources to the downstream reclosers).

The connection time of the next recloser after receiving feedback from the upstream one will be longer than the trigger time of the protection with the longest timing (automation will act after performing RAR cycles).

Any manual actuation of any recloser involved in the automation will lead to the automation being blocked, and the unlocking will be done by order from the Dispatcher.

Any loss of communication with any of the equipment involved in the automation will lead to the blocking of the automation, and the unlocking will be done by order from the Dispatcher.

For the analysis of the proposed solution, different failure scenarios were made, by zones, of some elements of the network, respectively:

- S1, S2, S3 energy sources;
- P01 - 20 kV OHL circuit breaker (A) - (C);
- P03 - 20 kV OHL circuit breaker (A) - (B);
- P02 Recloser KTR 1 (disconnected in normal operation);
- P04 Recloser KTR 141
- P05 Recloser KTR 306
- P06 Recloser KTR 452
- P07 Recloser KTR 550
- P08 Recloser KTR 402 (disconnected in normal operation)
- P09 Recloser KTR 1B - deriv. 20kV (F);
- P10 Recloser KTR 26 - deriv. 20kV (E);
- T1, T2 - JT Transformers (20 / 0.4kV)
- C01 Area that cannot be powered automatically. (if P01 triggers, only C01 is unusable)

Figures 4.17 - 4.23 show the general diagrams with the fault zones in the analyzed network and its state after power supply (state after resumption / power supply, red = dark, green = light):

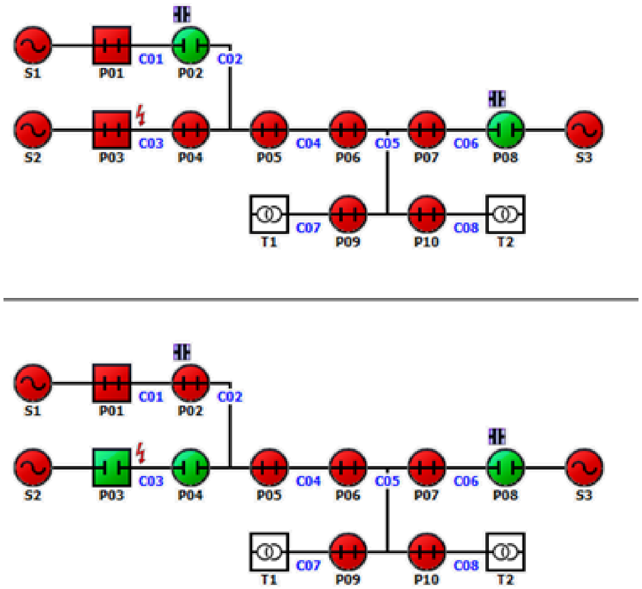

Figure 4.17. Defect in zone 1 (C03)

Table 4.10. "SAIDI" (year 2) for the analyzed network with and without automation.

Name LEA 20kV	**Year studied**	**SAIDI Initial (min)**	**SAIDI automation (min)**	**Reduction SAIDI (%)**
LEA 20kV (A)-(B)	2	2808.7	999.77	64.4

Chapter 5.
Conclusions

5.1. General conclusions

The widespread integration of power electronics and intelligent control systems in end-user devices and installations has led to a growing concern about the quality of electricity supplied to consumers. Therefore, automation systems based on the widespread use of digitization are of great importance in the operation and management of the distribution network. Data acquired with the help of modern sensors and the processing of this high volume of data, almost in real time, provide distribution operators with information on the status of the system at times and the need for a quick response in the event of disturbances.

Particular attention has been paid to the indicators that define the characteristics of the food service, in order to assess the efficient operation of consumer facilities, so that there are no changes in industrial processes that could lead to significant economic losses.

Measures such as establishing an appropriate configuration of the distribution network and adopting a structure appropriate to its operational management are necessary to ensure the quality of electricity supplied to users within acceptable limits.

The paper analyzes the existing and future configurations of electricity distribution systems, the disturbances that may occur and their characteristics, means of monitoring quality indicators and their characteristics, equipment that provides information about them.

The information needed for the operational management of distribution networks, the organizational and hierarchical structure of decisions, as well as the detailed knowledge of the possibilities allowed by automation systems play a key role in achieving the conditions to respond effectively to unwanted disruptive events. The protection scheme in the station in case of events in the electrical network is of particular importance, and its proper parameterization ensures a quick and selective response to disturbances.

The network communication system, the SCADA system as well as the measures adopted to limit the affected areas of the electricity network with the help of reclosers directly influence the continuity in the power supply of the users served, these solutions being analyzed in the paper.

The case studies and analyzes in the paper highlight the defects that may occur in the electricity distribution networks, the sequence of measures to limit the impact of disturbances, as well as the effects on electricity quality and continuity in power supply.

5.2. Personal contribution

In his dissertation, the author addressed important issues of current distribution systems based on a careful analysis of the extensive bibliography in the field, his own experience and tried to provide personal solutions to problems encountered during the study on continuity in power supply to consumers.

The main personal contributions to the development of the field are the following:

- presentation and detailed analysis of electricity quality indicators provided to users, specific to electricity distribution networks;
- highlighting the effects of low levels of electricity quality on users;
- analysis of the problems that appear in the service of users' supply and of the solutions for increasing the level of electricity quality for the more demanding users;
- analysis of the transition from existing distribution systems to the “smart grid”, highlighting the specific problems regarding the monitoring and analysis of the disturbances that may occur;
- study of the operational management of electricity networks with emphasis on its importance regarding the quality of electricity provided to users;
- identifying the effects of a low level of continuity of supply and quality of electricity on consumers and solutions to compensate them for damage;
- use of time variation of indicators to take measures to increase the quality level of electricity;
- the logic of the proposed automation installation and the necessary settings of the protections;
- case studies on events in the electricity distribution network;
- case studies on determining the performance indicators of the distribution operator for different scenarios;

- assessment of the impact on the continuity indicators of the electricity supply in a distribution network.

5.3. Prospects for further development

In this sense, the continuation of studies in the field may concern:

- means of reconfiguring the network to achieve a superior indicators for the power supply service;
- new indicators of electricity quality for micro-networks operating insularized;
- new indicators of electricity quality in the microgrids connected to the public electricity network by means of electronic transformers;
- the influence of the new structures of the distribution networks on the quality indicators of the electricity;
- modern protection systems in microgrids with active energy sources (renewable energy sources, storage systems, etc.);
- distribution systems with advanced self-assessment and self-repair functions.

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