MODERN SCADA SYSTEMS THAT CONTRIBUTE TO THE IMPROVEMENT OF DISTRIBUTED ELECTRICITY QUALITY

SISTEME SCADA MODERNE CARE CONTRIBUIE LA CREȘTEREA CALITĂȚII ENERGIEI ELECTRICE DISTRIBUITE

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***Abstract**: This paper presents a modern SCADA (Supervisory Control and Data Acquisition) system implemented at Distribuție Energie Oltenia for the operational control of the electricity distribution network. The advantages of such a system over the one it replaced are detailed, including: data acquisition from the DEO system and third-party systems (Transelectrica via ICCP protocol), the transfer of this data to analysis and optimization applications, and the possibility to implement functionalities such as fault location, isolation, and supply restoration (self-healing). These features contribute to improving the quality of distributed electricity by reducing the continuity indicators related to electricity supply interruptions.*

***Keywords:** supervisory control and data acquisition - SCADA, self healing, sistem avansat de management al distributiei - ADMS*

***Rezumat:** Lucrarea prezinta un sistem supervisory control and data acquisition - SCADA modern implementat in Distributie Energie Oltenia pentru conducerea operationala a retelei electrice de distributie, controlul de la distanta al acesteia prin monitorizarea si comanda de la distanta a echipamentelor telecomandabile. Se detaliaza avantajele unui sistem*

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SCADA modern in comparatie cu sistemul inlocuit, printre care, posibilitatea de realizare a unor logici care sa contribuie la cresterea calitatii energiei electrice distribuite prin scaderea indicatorilor de continuitate in alimentarea cu energie electrica. De asemenea, sunt prezentate functiile pe care SCADA le realizeaza pentru modulele unui sistem avansat de management al distributiei, prin marimile analogice si logice furnizate in timp real intregului sistem.

Cuvinte cheie: *supervisory control and data acquisition - SCADA, self healing, sistem avansat de management al distributiei - ADMS*

Abbreviations:

ADMS – Advanced Distribution Management System
CPT – Own Technological Consumption
DEO – Distribuție Energie Oltenia
DMS – Distribution Management System
GIS – Geographical Information System
IT/MT/JT – High/Medium/Low Voltage Levels
OMS – Outage Management System
RED – Electricity Distribution Network
SAP – Database System
SAIFI – System Average Interruption Frequency Index
SAIDI – System Average Interruption Duration Index
SCADA – Supervisory Control and Data Acquisition

Contributions

In this paper, the authors present the modern SCADA system implemented within Distribuția Energie Oltenia, referring to the system's structure with a description of its main components, being part of an advanced electrical energy distribution management system. The advantages of implementing such a SCADA system, the improvement and optimization of processes within the operational command activity are presented. Furthermore, the possibility of performing network automation directly within the SCADA system, benefiting from the self-healing function, is detailed. The dispatcher support function, performed by one of the ADMS modules (distribution network analysis - DNA) using restoration scenarios and real-time data provided by the SCADA module in incident situations, is also described. The concluding section presents aspects that, through the implementation of such a complete system, lead to the improvement of the quality of the electrical energy distribution service.

1. Introduction

The electricity sector has undergone substantial changes in recent decades, both due to changes in its organizational systems and determined by the emergence of a significant number of new electricity generation and utilization systems. In this context of distributed generation, the distribution system operator must quantify and reduce disturbances that occur in the electrical network, especially those concerning voltage, but also powers that can change direction and influence the quality of electricity distribution depending on the generated and consumed quantity.[1]

The response of a modern SCADA system to problems of improving electricity quality can be encompassed in two main directions:

– Acquisition of sufficient data volume from the process and making it available to analysis and optimization applications.

– Implementation of automation in network areas to improve continuity of supply to users, under the conditions imposed by the Performance Standard [2].

2. Implementation of an ADMS system in Distribuție Energie Oltenia (DEO) with a modern SCADA module, as a prerequisite for transitioning to a smart grid

Arguments for implementing digitalization technologies

The energy system faces challenges related to old infrastructure, continuous growth in energy demand, the integration of an increasing number of variable renewable energy sources, the emergence and future growth of electric vehicles, the need to improve energy security, and the necessity to reduce carbon emissions. All these factors necessitate a transition to a digital network that allows and provides:

- User participation in the energy process.
- Access for all sources and consumers.
- Development of new products and services, representing an opportunity for users.
- Flexibility for adapting rules to operating and market conditions.
- Advanced control methods, monitoring of key components, allowing rapid diagnosis and solutions for events and operating regimes affecting electricity quality.

- ➢ Optimization of asset utilization, continuous evaluation of their capacities.
- ➢ Reaction to unexpected events, network resilience in such situations.

One of the solutions for solving the multitude of problems in an electrical network and aligning with current trends and recommendations is the implementation of technologies and systems that allow the measurement, analysis, and control of the energy process involving both electrical distribution network operators, as well as producers and consumers.

The energy distributor must implement real-time data acquisition systems, analysis systems, automation systems, and provide a rapid response to various situations that may arise in the safe operation of an energy system.

DEO's solution in this regard was the acquisition and implementation of an ADMS system, an advanced distribution management system, a software platform that supports the management and optimization of the distribution process. ADMS includes functions that automate network restoration in case of outages and optimize the performance of the electrical distribution network.

ADMS is a decision support system that ensures operating personnel (dispatchers and field personnel) can efficiently monitor and control the electrical distribution system, while improving safety and service quality, and emergency response. ADMS allows greater accuracy in system analysis, modeling, and network regime calculations.

From a process perspective, DEO is responsible for ensuring the operation of the electrical distribution network, its maintenance, and expansion. Development projects for IT and process systems must primarily consider the company's strategic plan and the regulatory environment.

The evolution of technological systems in DEO is moving towards the complete integration of the SCADA system/module, DMS and OMS modules, and the integration of the system into the existing environment of other systems.

Achieving significant results in using such a system is facilitated by:

- – The ability to monitor and control electrical substations and equipment in the MV network.
- – Widespread use of reclosers and remote-controlled disconnectors.
- – Use of voltage regulators.
- – Use of fault indicators and fault locators.

Factors that favored the implementation of ADMS in DEO:

- – Development of the SCADA system (110 electrical transformation substations and over 1500 medium voltage network equipment integrated into SCADA).

– Perspective of SCADA system development, according to future programs.

– Personnel experience in using the SCADA system (dispatching and operational command support departments, operating personnel).

– Use of information from the SCADA system by non-operational personnel.

– Training of personnel who implement and maintain the SCADA system.

Normally, the low-voltage (LV) network is not included in process IT systems due to its size and dynamic nature. However, the increasing importance of utilities and evolving regulations require that it becomes visible in the distribution network model for management and operational optimization. The operating and management model must be transformed so that the LV network becomes dynamic and integrates increasing volumes of renewable energy solutions, EV charging solutions, and in the future, energy storage.

Considering the LV level, a global image of the network and resource visibility is achieved. It allows for network operation optimization, intervention control, and increased operational safety.

3. ADMS System Architecture and Component Modules

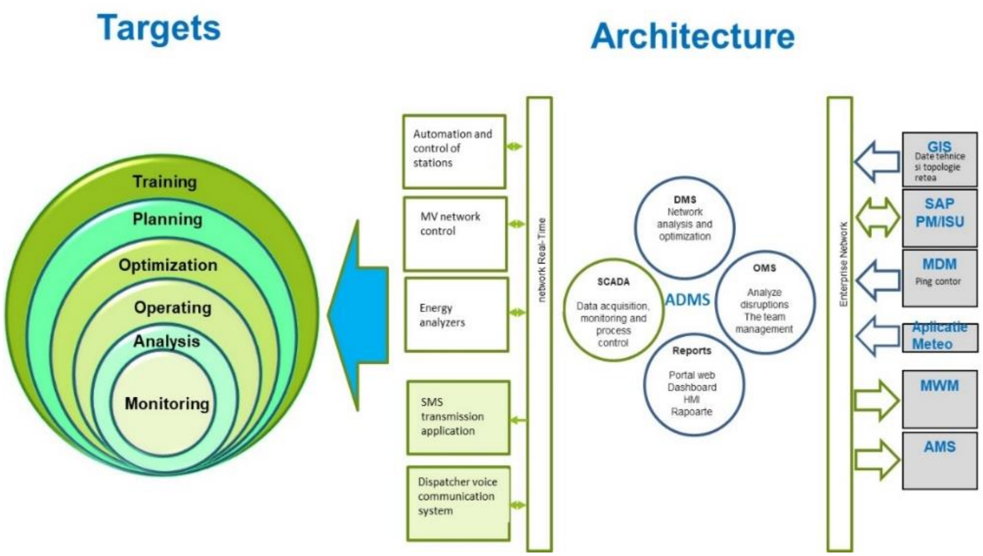

Fig. 1. ADMS system architecture and its objectives.

SCADA Module

The implemented SCADA module replaces the old SCADA system and adds new functionalities:

- Data acquisition from third parties via EMS SCADA Transelectrica using the ICCP protocol;
- Creation of redundant communication channels;
- Full system redundancy;
- Making all acquired data available to analysis and optimization applications;
- Implementation of automation in network areas.

Representation of data acquisition and transmission to the ADMS modules

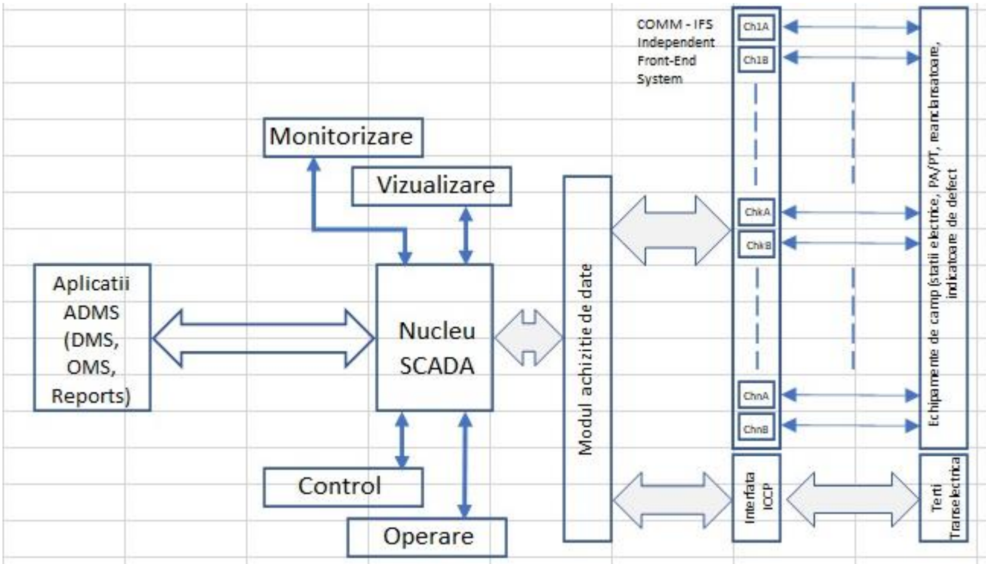

Fig. 2. SCADA module as part of the ADMS system

4. Functions of the SCADA Module

Background

– Independent Front-End System (IFS) – manages communications with RTUs and primary data acquisition, based on IEC 60870-5-104 protocol

– Digital and analog data processing

– Monitoring and control
– HIS – Historical Information System

Tools

– Information model management (IMM, SCADA Editor)
– Mod Studio

User interface

– User administration
– Operation modes (Real-time, Study, Replay)

Monitoring

– Event logs
– Alarming
– Limit control

Visualization

– Network diagrams
– Temporary elements
– Operational dashboard

Operation

– Diagram-based operation
– Operational dialog

Control

– Commands for switching equipment, protection, and automation
– Management and execution of switching scenarios

The SCADA system is the main data source for the ADMS system. It manages the acquisition and processing of over 500,000 data points (digital and analog). It also provides this data volume to other ADMS applications for energy process analysis, optimization, and outage management [3].

5. ADMS Modules and Thei Functions

DMS – Distribution Management System

Distribution Network Analysis (DNA)

● Power flow management – calculates network states under different configurations and loading conditions

- State estimator – provides statistical estimates using measured values, active/reactive power consumption, and error detection in measurements
- Short-term load forecasting – provides load planning data up to one week
- Fault location, isolation, and service restoration (FLISR) – assists in locating interruptions, determining switching steps to isolate and restore service
- Network reconfiguration optimization – determines optimal switching actions to minimize losses or manage voltage levels
- Voltage Var Control (VVC) – manages voltage/reactive power and reduces losses

SINCAL

a flexible graphical interface that provides users with functions for network creation (modeling), editing, evaluation, and protection calculation.

TNA - Transmission Network Analysis

110 kV network analysis applications, used to perform real-time and study-mode analyses." "110 kV network optimization applications, used in study mode to provide optimal network operation schemes and to identify congestion situations.

OTS – Operator Training Simulator

Simulator for dispatcher training with specific switching operationsand various incident resolution scenarios.

Load / Renewable Energy Forecast

Load forecasting based on weather information (temperature and solar radiation) Renewable energy source forecasting Loss forecasting

OMS Outage Management System

Outage Management (OM) is the ADMS module used for managing network faults. It is integrated with external systems through the ESB:

– Meter Data Management (EnergyIP);
– Mobile Workforce Management (via SAP);
– Customer Information System (SAP-ISU);
– SMS alert system;

– Weather prediction system and alerts from the meteorological authority.

Support for OMS Users

- Monitoring and recording unplanned outages;
- Planning, monitoring, and recording planned outages;
- Fault call handling and management;
- Network management during extreme weather events;
- Visualization and analysis of OM data (reports, dashboards).

Raports

The module allows generation of predefined reports related to dispatcher activity and outages:

– DASf-Station Template;
– DASf Normative;
– Characteristic Day;
– Manual Disconnection Norms;
– Limitation Norms;
– OMS reports – planned/unplanned outages, continuity indicators, compensation payments.

It also allows the administrator to dynamically create ad-hoc reports based on process needs [3].

6. Improving Electricity Quality Through Distribution Network Automation

At the electricity supply level, the main principle pursued is reducing the number and duration of faults in the distribution system.

By automating medium-voltage (MV) power lines, the aim is to enhance supply reliability for consumers, improve RED (Distribution Network) performance indicators, and increase the quality of distributed electric energy.

Self-healing automation is intended to identify the fault location, isolate it, and restore power to the unaffected MV network area.

In Figure 3, the automation for the MV network area corresponding to the 110 kV/20 kV Schitu Golesti substation is presented, implemented using breakers from the MV cells of two feeders (Musătești and Stâlpeni) and six reclosers in the MV network, including a loop recloser between the two MV lines.

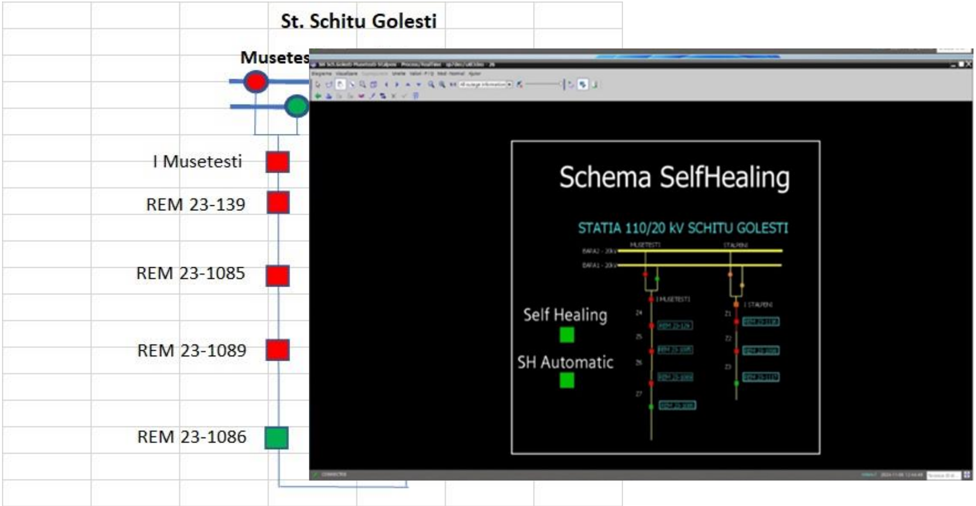

Fig. 3. Automation diagram for two MV lines (SCADA schematic capture).

Operating principle:

Fault location identification

- Tripping of a breaker within the automation system (example: trip of REM 23-129, which implies the occurrence of a fault in the area between REM 23-129 and REM 23-1085)

Fault zone isolation

- Automatic disconnection of the breaker downstream of the identified zone to create conditions for supplying the network without the fault (example: REM 23-1085 is automatically disconnected)

Supply restoration

- Automatic closing of the loop breaker to supply the fault-free network area (example: REM 23-1086 – loop equipment – is closed)

Operating conditions :

– All equipment in the automation scheme must have communication
– All devices must be in normal operating state
– Automation must be enabled

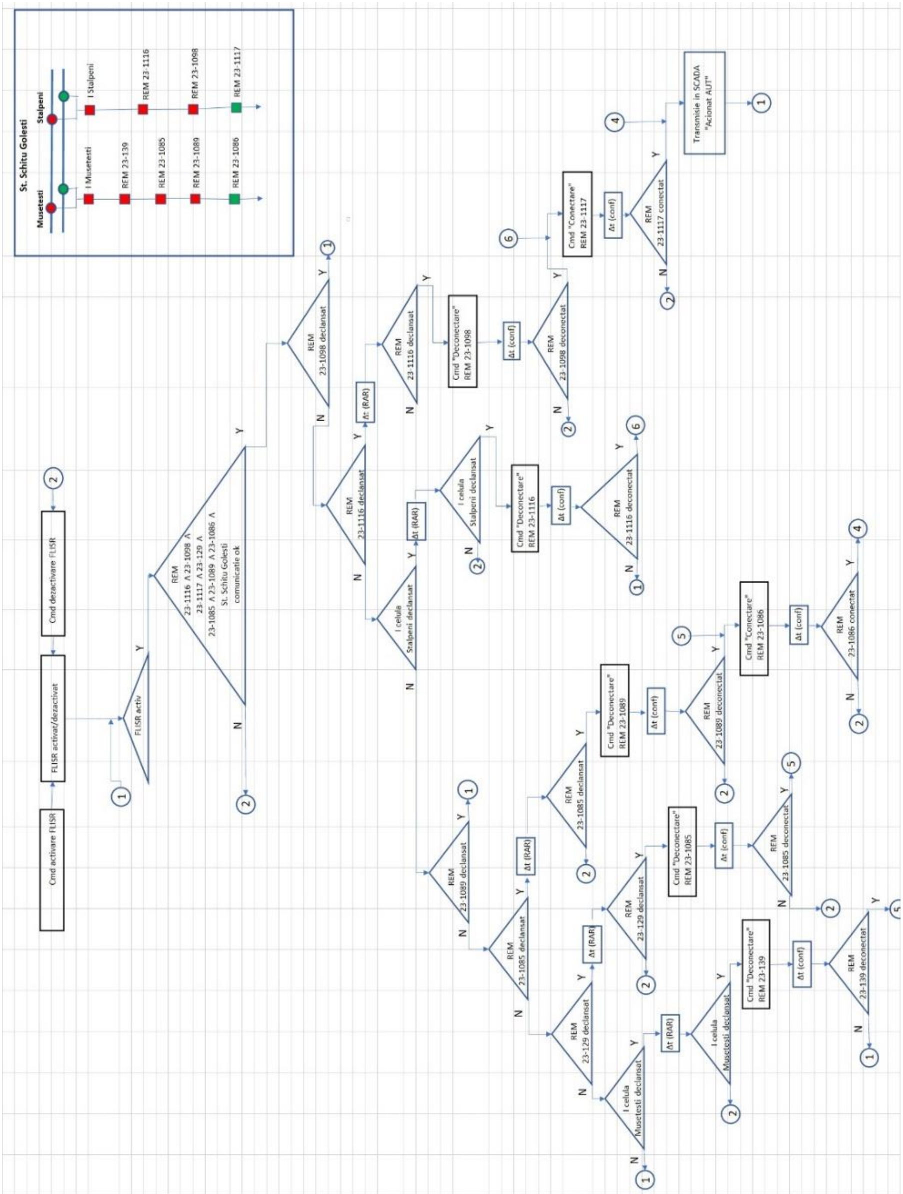

Fig. 4. Logical diagram of the automation.

Controls imposed in the operating logic:

– All commands for switching equipment will be accompanied by status verification following the executed commands.

– The logic operation accounts for the RAR pause (2 seconds).

– Any discrepancy (communication interruption, no response to switching operations, etc.) leads to blocking the automation operation; unlocking can only be performed manually by the dispatcher.

7. Conclusions

This work is based on the implementation of a modern SCADA system, described as an integral component of the Advanced Distribution Management System (ADMS), which consolidates both remote supervisory control of the electrical network and its continuous monitoring and analysis.

The system facilitates automation within the medium voltage (MV) network to identify fault locations, isolate faulted sections, and rapidly restore supply to consumers. It is designed for scalable expansion across the entire MV network, thereby significantly impacting continuity indices such as SAIFI and SAIDI. Moreover, the system provides restoration scenarios for incident management within the MV network, which can be manually selected and executed by the dispatcher, substantially enhancing continuity performance.

Sophisticated tools are incorporated for a range of steady-state and fault condition analyses, fault location indication based on data from network fault indicators, and the generation of automated or on-demand reports. These features support operational command activities and improve operational efficiency by automating tasks that are challenging to perform manually [4].

The ADMS, encompassing the modern SCADA system outlined herein, is currently undergoing comprehensive functional testing across the entire DEO network. It is expected to be fully operational shortly, leveraging all available module functionalities. The ultimate objective is to establish an operational framework that significantly enhances both the continuity and technical quality of the distributed electrical energy supply [4].

R E F E R E N C E S

[1] *E. Butoarca, D. Ursu, I. Marin* et al., Digitalization of Distribution Network Operations for Improving the Electric Power Distribution Service, CEE – Targoviste, 2019.

[2] Performance Standard for Electric Power Distribution, Order of the National Energy Regulatory Authority No. 46/01.07.2021, supplemented by Order of the National Energy Regulatory Authority No. 64/31.03.2022.

[3] *Siemens*, SCADA System and ADMS Modules Implemented in DEO, 2022–2024.

[4] *E. Butoarca, D. Ursu, I. Marin, C. Moanta* et al., Advanced Electric Power Distribution Management System, CNEE – Sinaia, 2024.