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ABSTRACT BOOK

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SESSION 1 – NETWORK COMPONENTS

Garant: David Mezera, EG.D, a.s.

MODULAR BATTERY STORAGE UTILIZING USED BATTERIES FROM E-MOBILITY

Milan Kloubec, ELTRAF, a.s.
Casper Scheltinga, Time Shift BV

The current global trend is to implement large-capacity battery electricity storage connected to distribution and transmission systems. This paper focuses on the latest experiences with the use of large battery stations in the electricity system and the possibilities of applying used batteries from electric vehicles in large-scale battery electricity storage. The paper also presents selected implemented projects of large-capacity battery energy storage using used batteries from electromobility.

BATTERY STORAGE AS MEASURE FOR BASIC TASKS PERFORMED BY DISTRIBUTION SYSTEM OPERATOR

Dominik Bokšanský, Milan Danko, Peter Frák, Matúš Kolej, Robert Mergeš, Jozef Michlík, Michal Pršanec, Jozef Tomčík, Východoslovenská distribučná, a.s.

In the context of the global electricity industry, the battery energy storage system ("BESS") is becoming a part of the electricity systems mainly due to its dynamically evolving technological characteristics for several reasons, primarily its ability to store electricity in a specific volume and to provide it at the time of power demand. Whether on the side of consumers, producers or electricity traders, the application of BESS becomes one of the tools to optimise the impacts resulting from energy requirements changing over time and the real availability of these energies. One of the basic tasks of the distribution system operator is to provide safe and reliable distribution of electricity while respecting its quality parameters. At the same time, when deciding on the development of the system, the distribution system operator is obliged to take into account the need to ensure that the energy efficiency of the distribution system is managed in such a way as to improve the energy efficiency of the distribution system without additional new investments in distribution facilities. The above mentioned current technical and legislative framework led Vy-chodoslovenská distribučná, a.s. to the decision to make use of the available technological features of BESS and to install a battery storage facility in the Bachledova dolina locality in the High Tatras. The storage thus became an integral part of the distribution system facilities with the functionalities of the above-mentioned technical requirements, while being aware of social responsibility and minimizing interference with the environmentally significant area. The basic technical parameters of this solution are rated power of max. 630 kVA, usable capacity at each moment of the defined lifetime at full discharge (DoD 100%) of at least 1200 kWh. The energy management system meets the following operating modes: 1. automatic power regulation depending on voltage (P/U or Q/U), 2. manual adjustment of the operating point of the P/Q diagram, 3. islanding mode of part of the distribution system. This paper describes the basic functionalities of this BESS and the solutions associated with the technical challenges in installing and operating such a device.

STATE TO ART TRENDS IN WORK SAFETY REGARDING THE POWER EQUIPMENT

Jan Pígl, SAFETySOL

This paper will discuss the application of the FMECA methodology to the risk assessment of switchgear in terms of arc flash. The input for the assessment is the calculated incident energy according to the IEEE1584TM-2018 standard (the approach applied in the USA) or the arc flash energy according to DGUV Technical Report 203-077 (the approach currently preferred in Germany). In this paper, both methods will be discussed in detail including a proposed flow chart for applying the FMECA methodology to a specific switchgear. The application of this methodology should result in the selection of appropriate protective measures including PPE, which will also be discussed in the paper.

GIS MONITORING – METHODS, MEANS, MODEL SOLUTIONS

Václav Straka, "TMV SS" spol. s r.o.

Monitoring in general is one of the means of reducing the risk of operation and at the same time the technical and economic impact of a possible failure. Monitoring enables a significant proportion of faults to be detected at a very early stage and thus a decision on corrective action to be taken at a time when the plant is not yet decommissioned by the protection systems. In the area of GIS monitoring, the paper focuses on the monitoring of key SF6 parameters and in particular the monitoring of the occurrence and nature of partial discharges in GIS. The paper also includes an overview of the most common faults, their detection methods and a demonstration of the technical solution for such monitoring. Standards relevant to this area will also be mentioned.

TESTING OF DENSOSTATS INSTALLED ON SF6 ELEMENTS

Václav Straka, "TMV SS" spol. s r.o.

Densostats are not only one of the elements enabling to monitor the pressure drop in gas-tight compartments, but due to their nature they are also an integral part of the protection of the elements from the HV level. The subject of this paper are references to the legislative framework together with a description of the possibilities of their testing with an impact on increasing the reliability of operation of power elements containing gas-tight compartments filled with SF6.

DESIGN AND IMPLEMENTATION ISSUES OF BLOCK BASEMENT FOR FRAMED STRUCTURE POLES OF DISTRIBUTION SYSTEM OPERATOR

Petr Lehký, Jan Zavadil, EGÚ Brno, a.s.

The paper deals with the design and construction of block foundations for truss towers of distribution system operators. The current state of affairs, where the pressure for excessive use of steel reinforcement, various concrete additives and higher strength classes of concrete is increasing, leads to considerable cost overruns and high technological requirements in the construction of truss tower foundations.

INTERIM RESULTS OF MEASURING THE ICING HEIGHT GRADIENT AND THE MASS OF ICING ON AERIAL WARNING SIGNS FOR THE HV AND EHV LINES

Jan Zavadil, Petr Lehký, EGÚ Brno, a.s.

The paper presents the interim results of the measurements of the mass of frost depending on the height above the ground on the meteorological mast in the area between the JED and the Slavětice substation and the measurements of the mass of frost on the balls of the warning aerial markings at the frost measurement station in Studnice.

CALIDUCT – CABLE LOAD CRITICAL POINTS

Milan Singer, konzultant, důchodce

In the current periods of high summer temperatures and drought, we have to take into account increased temperatures and soil resistances when sizing 22 and 110 kV cables. These influences can significantly reduce the load capacity of the cables. Further reductions in the load capacity of the cables, the so-called critical points of the route, may arise in particular from the warming of the surface of the cables by other local heat sources in parallel or crossing heat pipes, hot water pipes and steam pipes.

There is no prescription for the warming of cables by heat pipes. In different countries, this problem is solved in different ways: by special cable layers, insulation between heat pipes and cables, calculation by physical and mathematical models. The present report, based on available literature and measurements, suggests that the basis for the solution may be the relationships used in calculations of the mutual heating of cable lines (similarity of pipes and cables). Therefore, similar formulae from the relevant cable regulations can be used to approximate the cable warming by concurrence and crossing with the heat pipes in a sufficiently safe way.

The report shows that the values of cable thermal conductors insulated with modern, high quality materials are relatively low and that the crossing of cables with thermal conductors may not be the most critical point of cable loading for 22 and 110 kV cables, especially when the effect of mutual heating of the thermal conductors by cable losses is taken into account.

EXPERIENCE WITH GROUNDING MEASUREMENT METHODS - PRELIMINARY RESULTS OF A QUESTIONNAIRE SURVEY

Václav Vyčítal, David Topolánek, Petr Toman

In the framework of the Cigré B354 working group "Earthing System Testing Methods - historical approaches, recent developments and recommended approaches" a questionnaire mapping the real experience with earthing measurement methods was developed. The questionnaire focuses on virtually all types of measurements, ranging from basic methods of measuring soil resistivity, earth resistance, visual inspection to more complex methods of measuring contact voltages, evaluating earth continuity, or inspecting earthing systems e.g. after a fault etc. The questionnaire survey then focuses on earthing systems of HV and above and further maps the experience with the methods used practically across all continents.

The proposed paper will thus deal with a cursory description of the basic measurement methods and its principles and will be complemented by some preliminary results of this ongoing questionnaire survey. In briefly describing the methods, emphasis will be placed on listing the parameters that may differ from one measurement procedure to another and that have just been surveyed in the context of

the questionnaire survey conducted. After this brief analysis, the paper will be supplemented with some preliminary results already obtained. The paper should also serve to promote more widely that ongoing questionnaire survey, which will still be available to complete at the time of the conference, and thus the presentation of these results to the wider technical community could lead to a wider range of responses.

SYSTEM FOR AUTOMATED CREATION OF PROJECT DOCUMENTATION FOR SMART SUBSTATIONS

Karel Schmidt, PREdistribuce a.s., Josef Fritschka, TECHNODAT Elektro s.r.o.

The paper describes a solution for the creation of project documentation of a smart substation control cabinet and the management of type wiring. PREdistribution builds dozens of smart substations in different configurations every year. The control cabinet project documentation is based on the type wiring for different combinations of elements. The deployment of a database design system with automatic variant creation functions simplifies and speeds up the management of type wiring and its changes. Process-wise, we were inspired by the ISO 19650 standard, which describes the management of information between the commissioning party - the investor and the commissioned party - the designer.

SESSION 2 – POWER QUALITY AND EMC

Garant: Martin Kašpírek, EG.D, a.s.

DEVELOPMENT OF REVISIONS OF EN 50 160 STANDARD

Martin Kašpírek, David Mezera; EG.D, a.s.

The paper describes the current version of the draft ed.4 of EN 50 160 in relation to changes and revisions in relation to the previously valid ed.3, then the current status of the approval process, or the release of the standard. The implications of the standard for the operational practice in the Czech Republic and possibly also for the related energy legislation are discussed.

IMPLEMENTATION OF EN 50 160 INTO THE TRANSMISSION SYSTEM OF THE CZECH REPUBLIC

František Rajský, Michal Šerks; ČEPS, a.s.

The Czech Republic power transmission system is one of the most important parts of not only the Czech but also the European power system. The task of the CEPS operator is to ensure its proper functioning, operational safety and the required quality of electricity. That is why the Power Quality Diagnostics Department is now an integral part of the system. The department oversees respect and compliance with the power quality parameters defined not only by the European standard EN 50160 Voltage characteristics of electricity supplied from public grids, the PS Code and connection conditions. The conclusion outlines the future of power quality measurement in the transmission system of the Czech Republic.

CALCULATION EVALUATION OF PLANT CONNECTIVITY REGARDING THE IMPACT ON DISTRIBUTION SYSTEM

Jan Jiřička, Martin Kašpírek, Martin Kurfiřt, Zdeněk Máca, Daniel Kouba; EG.D, a.s.

The basic rules for assessing the connectivity of generating plants to the DS are described in Annex 4 of the PPDS. With the current high penetration of RES, there are overflows of active power from lower to higher voltage levels and the question is how to take this into account in the calculations. Similarly, the correlation between the installed capacity of the generating plant, the inverter rated capacity and the reserved capacity (Rv) of the generating plant needs to be discussed, taking into account the actual potential impact on the power grid. For example, it is possible to consider generators with implemented Q(U) and P(U) characteristics for connection at the LV level - but these must be correctly set up and operational throughout the life cycle of the generator. The issue of voltage limits of connectivity and the possibility of connecting generating plants with Rv=0 in closed areas is discussed. Finally, practical examples of plant connectivity calculations are given, e.g. the problem of the influence of voltage ratios by plants on adjacent outlets or the connectivity of a load point of the plant-battery combination type are addressed. The paper is then intended to contribute to the discussion on the revision of the existing methodology for assessing the connectivity of generating stations in order to find possibilities for connecting additional customers, under the conditions of compliance with the voltage ratios in the network defined by the standard ČSN EN 50 160.

POWER QUALITY IN DISTRIBUTION SYSTEM FOR EACH VOLTAGE LEVEL AND FOR ALL DISTRIBUTION SYSTEM OPERATORS

Jan Petrásek, František Kysnar, Josef Hrouda, EGC – EnerGoConsult ČB s.r.o.

The paper "Voltage quality in the distribution network" deals with the evaluation of the monitored parameters of the quality of electricity supply; the transfer points between the TS and DS, 110 kV customer points, 110 kV/VN substations are evaluated. The evaluation is carried out by looking at both

continuous phenomena and voltage phenomena. Regular half-yearly intervals of voltage quality assessment provide insight into the long-term evolution of the monitored characteristic parameters - voltage magnitude, Plt, Pst, uu, THDu. PS/DS transfer points have been evaluated since 2006. The paper summarizes the results of the evaluation, lists the problematic parameters at the measurement points where the required limits according to EN 50160 are not met.

PQ CENTER – ANALYTIC TOOLS IN PREDISTRIBUCE DISTRIBUTION NETWORK

Tomáš Sýkora, PREdistribuce, a.s.

Based on the successful implementation of the pilot project PQ Central, this application was switched to production mode in the first half of 2022. The application allows to display the evaluation of measured data both by selecting the measurement point and in the topology of the distribution network. Furthermore, advanced analytical tools over the measured data will be presented in the paper.

DISTRIBUTION SYSTEMS POWER OVERFLOW REGULATORS IN PROSUMER INSTALLATIONS: DEVELOPMENT OF COMMERCIAL DEVICES REGARDING THE POWER QUALITY

Jan Klusáček, Jan Morávek, Michal Vrána, Petr Mastný, Jiří Drápela; VUT v Brně – FEKT, UEEN
Jaroslav Kloud, Radek Křišťan; ČEZ Distribuce, a.s.

Active power flow controllers with controlled consumption in the installations of active customers (prosumers) have the task to consume locally generated surplus electricity so that it is not delivered to the distribution system, with a set value of active power to the DS. In practice, it has proved popular to control the heating coil output by switching, either 1) in pulse-width control mode by means of a) solid-state relays switched when the mains voltage passes zero, or b) triac control of the firing angle, or more recently 3) in pulse-width modulation mode, i.e. full modulation of the voltage waveform on the resistive coil by a step-down converter. The method of switching, and to some extent the method of control, often causes an otherwise linear resistive load to behave as a non-linear/time-varying load at the terminals, and moreover differently from phase to phase. In this paper, the behaviour of now commercially available installations in the Czech Republic is evaluated based on the criteria of the quality of current draw, the effect on the voltage in a realistic LV network and the dynamic response of the control loop to changes in load or generation in the installation. In addition, the paper demonstrates the energy measured by a typical electricity meter after a control intervention.

OPERATION OF DISTRIBUTION TRANSFORMERS WITH 22/0,4 KV AND 22/0,42 KV CONVERTERS IN THE DISTRIBUTION NETWORK OF SSD A.S. IN COMBINATION WITH CONNECTION OF FVE SOURCES AT LV LEVEL

Miroslav Dubovský; Stredoslovenská disrtribučná, a.s.

In areas with complex geography, it is often necessary to use longer 22 kV distribution lines for electricity distribution. Therefore, due to the expected voltage drops, distribution transformers with 22/0.42 kV gearing were installed at selected locations to eliminate the effect of the length of the 22 kV lines. However, the connection of small sources, in particular PV plants, to low voltage levels allowed by the legislation may lead to unwanted voltage increases and complications for both the operators of the small sources and the distributor.

SIMULATION MODEL AND EXPERIENCE WITH CONTROLED SUPPRESSOR IN THE CZECH REPUBLIC TS

Oldřich Rychlý, Karel Máslo, Tomáš Hába, Jan Tesař; ČEPS, a.s.

In December 2021 and January 2022, new voltage control elements were connected to the transmission system of the Czech Republic, which are regulated reactors. This paper presents the control method of the controllable inductor including simulation verification and comparison with real measurements. To show the coordination and cooperation of multiple control elements in one node, an example of controlling a controllable inductor and the Dlouhé stráně power plant in the Krasíkov pilot node is given. The MODES network simulator is used for simulation verification. The paper also describes in detail the model of the controllable choke and the modified ARN controller model.

INSTRUMENT FOR TESTING THE SOLAR PLANT USING MULTI-CHANNEL TRACKING OF CURRENT-VOLTAGE CURVE

Daniel Kaminský, Aleš Krutina, Jiří Hula; ELCOM, a.s.

This paper presents an innovative test rig for inspection and verification of the functionality of large-scale photovoltaic systems. This device helps to find and address significant losses in power generation. The principles of operation of the device, the testing methods used, the available results of the given tests and examples of different measurements performed will be explained.

PQ ANALYZATOR REQUIREMENTS – VOLTAGE AND CURRENT SENSORS

Jan Kraus, Miroslav Novák; KMB systems, s.r.o.

The paper describes the normative requirements for PQ analyzers with a focus on voltage and especially current sensors. Sensors and instrumentation are often used as if they were perfect.
We rely entirely on the measurement results obtained without questioning the quality of the results.
This paper will introduce the issue of accuracy of indirect current measurement with network analyzers.
It will summarize an overview of the available current measurement methods and methods for comparative measurement of sensor characteristics.
Measurement results of individual DUTs will be presented: frequency/phase characteristics, noise output parameters, transmission at signal with DC component and immunity to electric field.

SEKCE 3: OPERATION, CONTROL AND PROTECTION

Garant: Petr Toman, VUT Brno

OPERATIONAL EXPERIENCE REGARDING THE MOBILE CAPACITOR BATTERY (22 KV/5 MVAR) SUPPORTING THE VOLTAGE DURING LOAD CHANGES

Pavel Bürger, Josef Hrouda, EGC-EnerGoConsult ČB s.r.o.
Roman Vaněk, ČEZ Distribuce, a.s.

In November 2021, a 22 kV, 5.25 MVAr capacitor battery was commissioned to ensure voltage stability in the area supplied from the 22 kV Králíky switching station. Since then, the battery's operating parameters have been recorded and evaluated, especially its ability to influence the voltage level of the 22 kV level at the Králíky substation.

The paper describes the design and procedural functionalities of the battery power control according to the experience gained over time. At the same time, the monitored voltage quality parameters in SP Králíky in the long term are evaluated. In addition to the electrical parameters, other non-electrical parameters such as the effect of icing in winter, stability of room temperatures in the containers, and operational reliability of important components were assessed. The data provided by the telemechanics, the integrated energy analyzer and the documentation provided by the battery operator from the DRT database were used for the analysis.

FAILURES OF POWER SUPPLIES FOR MONITORING ELECTRICAL QUANTITIES IN DTS MN/LN

Michal Jurík, Jan Jiřička, EG.D, a.s.
Jan Souček, MEgA – Měřící Energetické Aparáty, a.s.

The paper deals with extraordinary failures of three-phase power supplies for the system of measuring parameters of electrical quantities in HV/NN distribution substations, which were observed during deployment and operation in the EG.D. distribution network. It describes the operational tests that were used to detect the cause of the faults (dynamic surge events) and the countermeasures taken by the instrument supplier.

CYBER SECURITY OF SMART NB-IO/LTE CAT M METERS – OPERATIONAL EXPERIENCE

Petr Mlýnek, Pavel Mašek, Radek Fujdiak, Ján Sláčik, VUT v Brně

This paper presents the experience of cybersecurity deployment under Decree 359/2020 with limited wireless technologies considered for selective deployment. The theoretical assumptions of the technologies together with full cybersecurity were verified by real measurements in selected sites with marginal signal levels and showed the necessity to account for the limits of wireless technologies with respect to cybersecurity requirements.

EVALUATEION OF VDIP SYSTEM FUNCTION DURING PARTIAL OPERATION IN VIMPERK AREA

David Topolánek, Václav Vyčítal, Vít Krčál, VUT v Brně
Jan Grossmann, ELVAC, a.s.
Jan Kraus, KMB systems s.r.o.
Michal Jurík, EG.D, a.s.

The paper focuses on the evaluation of a prototype Vdip system under realistic operating conditions. The Vdip system enables localization of asymmetrical faults in all types of high voltage distribution networks (compensated, isolated, resistive grounded), focusing mainly on the localization of ground connections. The prototype of the Vdip system was the subject of a three-year development within the TAČR project TK01020107, which ended with a semi-field trial in the compensated HV Vimperk system. It is the presentation of the results of this semi-operation, which included the installation of a total of seventeen voltage monitors on the LV side of the DTS that is the subject of the paper.

PRACTICAL EXPERIENCE WITH THE ELF7 HANDHELD DETECTOR FOR LOCATING GROUND CONNECTIONS

Jan Vaculík, EG.D, a.s.
Martin Horák, Západoslovenská distribučná, a.s.

The paper will deal with the technology for localization of ground coupling in compensated networks with an extinguishing choke. It will compare the approach to locating ground faults in EGD and ZSD distribution companies and evaluate the contribution of the ELF7 handheld detector in both distribution companies.

EXPERIMENTAL VERIFICATION OF THE USE OF GROUNDING OF THE AFFECTED PHASE AS AN ALTERNATIVE TO OZ

David Topolánek, Viktor Jurák, Václav Vyčítal, VUT v Brně
Martin Fabián, EG.D, a.s.

The paper presents the results of an experimental measurement performed on 12.5.2022 in which a new method for self-extinguishing single-pole faults in resistively earthed systems was verified using the concept of grounding of the affected phase (PPF) in the substation. The aim of the tests was to assess whether this method/concept allows self-extinguishing of fault current under realistic operating conditions without the need to shut down the faulted section, i.e. an alternative to automatic reclosing (AR). The evaluation of the test is mainly focused on the voltage drops on the LV sides of the distribution transformers (DTS) when PPF is applied and the ability of the fault current to reach a self-extinguishing level after PPF activation.

IMPLEMENTATION OF A GROUNDING ALGORITHM FOR THE AFFECTED PHASE AS AN ALTERNATIVE TO RECLOSING AND ITS TESTING USING A REAL-TIME SIMULATOR

Jurák Viktor, Topolánek David, Jaroslava Orságová, VUT v Brně

To extinguish a transient fault in resistive earthed high voltage distribution networks, automatic reclosing is used. However, this has a negative impact on the reliability of the power supply to customers, as a voltage-free pause must be ensured. A possible solution is to use the grounding system of the affected phase as a priority and only in case of an unsuccessful attempt to extinguish the fault to use a full restart cycle. By grounding the affected phase, it is possible to create self-extinguishing conditions for the fault current without interrupting the power supply. The aim of this paper is to describe the implementation of this algorithm in a commercially available REX640 terminal outlet and, in particular, to describe a method for testing the proposed configuration. For testing, a

real-time simulator is used to simulate the proposed network and to transmit the simulation results via analog outputs to the terminal. The terminal then reacts based on these values and sends real-time feedback back to the simulator. The terminal under test then forms a closed loop (Hardware-In-the-Loop) with the simulator. The terminal under test is then exposed to almost comparable conditions as in real operation. This helps to prevent errors that could occur in real operation and that could not be detected by normal secondary testing.

EQUIPMENT FOR EARTH FAILURE COMPENSATION

Tomáš Komrska, Jakub Talla, Zdeněk Peroutka, ZČU v Plzni

This paper presents a new technology for the compensation of ground faults in high voltage distribution networks. The key element of the new method of compensation of single-phase ground faults is the controlled active current source, which opens up completely new possibilities in the field of protection and brings significant progress in the safety and reliability of distribution system operation. The solution outperforms traditional passive quenchers, especially in its ability to compensate for all components of residual current, but it also symmetrises the network, does not operate at the problematic resonance point and eliminates the time-consuming tuning process.

SYNCHRONOUS GENERATOR DISTANCE PROTECTIONS – PROTECTION OF MACHINE AND ENVIRONMENT

Jiří Bermann, Hitachi Energy s.r.o.

The paper shows the purpose of generator distance protection for the generator itself, its connection environment and its connections to the surrounding network. It shows its interplay with the so-called block distance protection and its necessity both in the generator direction and in the grid direction. The need for fast and responsive generator block distance protection together with its commonly implemented differential protection and the importance of busbar backup protection of the adjacent grid substation and outgoing line protection are emphasized.

UNINTENDED ISLAND OPERATION OF 5 MW PVE

Roman Vaněk, ČEZ Distribuce, a.s.

RES operation is an integral part of our electricity system. The electrical equipment shall meet the standards in force at the time of commissioning. At the time of commissioning, most RESs had frequency protection settings of 50 ± 0.2 Hz. Island operation detection was designed to this frequency. How RES behave in the grid with the current setting of 47.5 Hz to 51.5 Hz is in my presentation.

OPERATION OF 110 KV VT WITHOUT 110 KV

Roman Vaněk, ČEZ Distribuce, a.s.

RES operation is an integral part of our electricity system. In the event of a long-term repair of a power line, we look for an alternative system connection. My presentation describes how we operated a 110 kV wind farm in U/Q control without a 110 kV power line using the great power prediction of the operator of that park.

PARAMETERIZATION OF THE NUMERICAL MODEL OF THE GRID SYSTEM FOR COMPARISON OF SIMULATION RESULTS WITH REAL MEASUREMENT RESULTS OF SELECTED NON-STANDARD EVENTS

Vít Krčál, Václav Vyčítal, David Topolánek, VUT v Brně
Jan Vaculík, Branislav Vavruš, EG.D, a.s.

The paper deals with the possibilities of parameterization of loads in an asymmetric lattice model for comparison of simulation results and real measurement data. Two approaches are used to adjust the model loads, one based on simulated power supply type diagrams selected based on the match with real measurements, the other using a state estimation tool based on DTS measurements recorded during tests. The results of the steady-state runs of the simulations and the measurement data are compared for several test scenarios performed reflecting exceptional network operating conditions. The aim is to evaluate the potential of the methods used for the estimation/parameterization of the numerical model of the system, to assess the fidelity of the numerical model and the behavior of the grid during non-normal events.

UNBALANCE IN THREE-PHASE NETWORK MODEL II.

Karel Máslo, ČEPS, a.s.
Jan Koudelka, Branislav Bátora, Petr Toman, VUT v Brně

The paper deals with the extension of the three-phase network model for the purpose of simulations of asymmetries, both asymmetric disturbances and inherent asymmetries in the system. The approach to modeling the individual components of the power system is described and its performance is demonstrated using simple simulation cases that have been validated using the PSCAD/EMTDC simulation program. The paper discusses future applications of the prepared model, namely in the areas of protection and automation testing, investigation of backflow effects and simulations of asymmetries caused by the power supply of the railway system. In addition to the applications already mentioned, the developed model will also be used for educational purposes.

APPLICATION OF A MODEL OF A HIGH-VOLTAGE ASYNCHRONOUS MOTOR IN A B 0 COORDINATES FOR MODELLING SWITCHING TRANSIENTS

Jan Pígl, SAFETySOL

In this paper, we will discuss the application of a mathematical model of the motor in the α β 0 coordinates to solve high frequency switching transients that occur during the tripping of a high voltage switch. We will first determine the model parameters and verify the simulation results with measured waveforms, and then simulate the above system in other operating states.

In this paper we will also discuss the measurement of switching transients at the high voltage asynchronous motor output and the accuracy of the measurements made.

SESSION 4 – DISTRIBUTED ENERGY RESOURCES AND ELECTRICITY USAGE

Garant: František Kysnar, EGC ČB s.r.o.

FLEXIBILITY IN DISTRIBUTION NETWORK

Aleš Krula, Radek Hanuš, Václav Růžek, PREdistribuce, a.s.

Recently, there has been a gradual opening of the electricity flexibility market. Flexibility providers are now connected to the HV and MV distribution networks. At the same time, steps are being taken to connect also LV flexibility providers. The behavior of flexibility providers at lower voltage levels may cause specific problems for the DSO, as distribution networks have not yet been built for this form of operation. Therefore, new operational and investment measures need to be put in place to continue to maintain the security and reliability of network operations. However, flexibility is also a tool that can bring benefits to the DSO if managed correctly. To this end, PREdi has developed a software application that determines the available capacity for flexibility transactions at individual LV outlets.

U/Q CONTROL IN CEZ DISTRIBUCE NETWORKS

Jan Švec, Roman Vaněk, ČEZ Distribuce, a. s.

The paper summarizes the principles and scope of voltage and reactive power regulation in the CEZ Distribuce networks, especially at voltage levels HV and MV. In connection with the gradual change of the resource base in the Czech Republic, the development of decentralized generating plants, changes in the load of transmission and distribution networks and the increase in cabling, there are more and more frequent situations when the voltage, especially in the transmission system, exceeds the upper permissible limits. This raises the need for sufficient and efficient U/Q control not only in the TS but also in the DS that are fed from this overhead system. ČEZ Distribuce is actively working to ensure that the reactive power regulation potential of the generating plants in particular is maximally used within the operating limits. The paper presents various approaches to control elements not only at the HV level but also at the HV level, which allow to contribute to the voltage stability of the whole system and to maintain quality parameters. It describes the management changes and forms of cooperation with the generation and DS operators that have been implemented in the past months and years, with the aim of the distributor actively contributing to the U/Q control not only for the needs of the distribution network but also for the whole EC. The DS and DS are physically connected by transmission transformers, where the distributor has a significant influence on the reactive power flow and thus contributes to the reduction of losses not only in the DS but also in the DS. Control approaches are also presented at the HV and MV levels, which, in addition to the above, aim to maintain voltage quality parameters in the DS. The future trend is then necessarily a higher involvement of U/Q regulation at the MV level also in the system-wide solution. Therefore, ČEZ Distribuce is developing activities in the area of decentralized control and optimization for the sub-feed areas of MV where available control actuators are present.

IMPACTS OF COMMUNITY AND MUNICIPAL ENERGY ON THE SETTLEMENT BALANCE

Milan Krátký, Tomáš Kolacia

The Czech Republic is currently witnessing a broader development of community and municipal energy. Legislative anchoring, subsidy titles and support for selected municipalities are underway or under preparation. The paper uses model examples to show how the expansion of a new type of generation sharing can affect the balance of selected building types and the balance of a settlement.

EVALUATION OF FVE INVERTER A1 IMMUNITY MEASUREMENTS DURING SHORT-TERM VOLTAGE DROPS IN THE NETWORK

Luděk Frejvald, ČEZ Distribuce, a. s.

The paper deals with the results of testing of category A1 PV inverters for resistance to short-term voltage drops and overvoltage in the grid.

VERIFICATION OF HYBRID INVERTER CHARACTERISTICS FOR 10 KW SOLAR POWER SOURCES

Richard Velička, David Vala, Vysoká škola báňská – Technická univerzita Ostrava

The large increase in demand for the installation of domestic solar has also led to an increase in the development of new inverters. This paper deals with the evaluation of the performance of one of the latest hybrid inverters to enter the market. The aim was to measure the power flows from the PV panels (the latter was simulated by a 10 kW DC source) through the inverter to the battery, to the load or to the supply to the grid (Grid). Measurements were also made of the supply from the battery to the grid, to a standard load or to a back-up output (EPS). The way the measurements were connected allowed to monitor the power at all inputs and outputs at the same time, and thus observe their switching. At the same time, the power losses on the inverter in the battery-to-load inverter function, both symmetrical and asymmetrical, were also monitored. To illustrate the characteristics of the inverter, time recordings of the voltage waveform at the backup output were also made, including a record of the rate of transition from Grid to EPS mode, i.e., during a grid failure.

COMPARISON OF THE FUNCTIONALITIES AND CONTROL CAPABILITIES OF SELECTED TYPES OF INVERTERS FOR HOUSE PV IN RELATION TO THE REQUIREMENTS: RFG, PPDS AND EN 50 549

Martin Kurfiřt, Tomáš Valta, Martin Kašpírek; EG.D, a.s.

The paper describes the required functionalities and control capabilities of inverters defined by the energy legislation: the RfG, Annex 4 of the PPDS, EN 50 549. The new EG.D, a.s. Clean Energy Laboratory, commissioned in November 2021, enables comprehensive testing and verification of A1 generation modules in different modes of operation of the load point, thanks to the power grid simulators. As the electricity distributor is responsible for the safe and reliable operation of the grid operated with voltage levels according to EN 50 160 and, due to the high penetration of RES, also towards the transmission system, it is necessary to verify the connected customer equipment (inverters) so that their behavior is predictable and in line with the required settings in real operation. The main output of the paper is then a comparison of different types of inverters, whose manufacturers (suppliers) most often offer their products to customers in the Czech Republic. The differences in the behavior of some types of inverters are marked, where some type series cannot be recommended for mass deployment in the distribution network.

THE EFFECT OF DISPERSIVE ENERGY SOURCES ON THE STABILITY OF THE POWER SYSTEM

Jaroslav Pospíšil, Protection & Consulting, s.r.o.,

The paper compares the dynamic properties of wind and photovoltaic power plants with conventional energy sources, i.e. synchronous modules.

The dynamic properties of wind power plants with bilateral power supply / DFIG / and with synchronous machines connected to the power grid via an electronic converter / FaRC / are analyzed. Photovoltaic generating plants are connected through an inverter.

Synchronous generation modules have the ability to withstand or slow down frequency deviations, a feature that renewable energy technologies do not have. Further development of renewable energy sources that do not contribute naturally to inertia could be facilitated by so-called virtual inertia / artificial inertia /. The idea of virtual inertia and its comparison with natural inertia is explained.

DEPENDENCE OF POWER ASYMMETRY AND DELIVERED ENERGY BY ASYMMETRICAL CONVERTERS IN LV NETWORKS

Michal Vrána, Jan Klusáček, Jan Morávek, Petr Mastný, Jiří Drápela;
Vysoké učení technické v Brně, FEKT ÚEEN
Martin Kurfiřt, Martin Kašpírek; EG.D, a.s.

Users of LV distribution networks with phase asymmetrical consumption and photovoltaic generation are motivated to install inverters that allow asymmetrical supply to individual phases due to the way energy is registered in meters in the Czech Republic. Thus, with appropriate control, the original asymmetry of active power at the interface of a given point of consumption, and hence in the whole network, can be significantly reduced. The main focus of this paper is the analysis of the behavior of commercial asymmetrical inverters in different operating states, which differ in the ratio of the controlled active power asymmetry in the phases and the actual PV panel power, with both shortage and surplus of generation plant power to cover the on-site consumption. Furthermore, methods of power redistribution to the phases are presented to help reduce the voltage asymmetry due to the distribution network background. The analysis is performed on a test bed with AC grid and PV panel simulators.

ANALYSIS OF THE USE OF POWER CONSUMPTION AND PRODUCTION PREDICTION FOR THE ADVANCED ENERGY MANAGEMENT SYSTEM OF A CUSTOMER SITE CONNECTED TO THE LV DISTRIBUTION NETWORK

Michal Vrána, Martin Paar, Michal Ptáček, Martin Vojtek, Vysoké učení technické v Brně

The prediction of electricity consumption and production and its corresponding consideration in the energy management system (EMS) is becoming increasingly important for the technical and economic significance of facilities combining decentralized electricity sources and battery/storage technologies. The implementation of the results of predictive analyses, as part of an advanced EMS, can then have a major impact on the concept of prioritization of the setup of the actual accumulation management and operation planning of selected appliances. These are not only important from the perspective of better utilization of electricity within the point of consumption, but can also be crucial in the context of possible dynamic electricity prices. Current EMS concepts are based solely on simple control or on the use of statistical methods. In the first case, the possibility of prediction is not exploited and the second approach does not achieve a sufficient level of accuracy, and the extent to which advanced prediction methods are applied depends on the nature of the point of use. The motivation and main objective of this paper is to analyze the possibilities of using prediction methods for selected type of objects connected to low voltage distribution networks and to point out their possible benefits or shortcomings.

USE OF SMART METER DATA FOR DISPATCHING CONTROL OF THE LV NETWORK

Jiří Mareš, Martin Šula, Michal Gála, EG.D, a.s.

In EG.D we are implementing a pilot project SMARAGD, which aims to install and test a smart meter system before the upcoming rollout of smart metering in the Czech Republic. The presentation will present the possibilities of using a smart metering system for LV dispatching: remote reading of data from smart meters and related use cases/functionalities for LV network management.

SESSION 5: DISTRIBUTION SYSTEM DEVELOPMENT

Garant: Jaroslav Šabata, EGÚ Brno, a.s.

CHARGING INFRASTRUCTURE IN DEVELOPER PROJECTS

Martin Lískovec, Jan Hejhal, Jiří Randa, PREdistribuce, a.s.

The preparation and construction of a medium-sized residential project in Prague today takes an average of ten years. Thus, the developer must respond to future demand for new trends in housing, be it air conditioning, heat pumps or electric car charging. Within the recharging infrastructure, specific requirements are already being placed on developers, which give a clear signal for the future in which direction the development of electric vehicle charging in development projects can be gradually applied. From the perspective of LV network planning, these new solutions also bring with them new power requirements and need to be taken into account in the calculation of the reserved power supply of the building in a given location. This paper presents a way of integrating electric car charging in new development projects in garages, i.e. non-public charging parking spaces for residents, from the perspective of PREdi's LV network design principles. It describes a model that works with measured data from continuous metering, current network design principles and, combined with the outputs of studies looking at EV charging, gives future insight into the impact on distribution network sizing.

EVALUATION OF INVESTMENT ACTIONS IN ČEZD USING THE SCORING CAPEX METHODOLOGY

Jan Berka, Adam Teringl, Štěpán Kubín, ČEZ Distribuce, a.s.

CAPEX scoring is a method for evaluating the benefits of investment actions in ČEZd. A "score" is calculated for each action, which is based on the effects of the action (impact on OPEX, SAIDI, losses, smart grids, etc.) converted to the value of the investment itself. Then, the whole portfolio is optimized in order to keep the budget, to meet the selected objectives (SAIDI, development of optical infrastructure, etc.) and at the same time to maximize the effect in OPEX reduction. The result is a prioritized action plan in the form of a recommended layout for each year of implementation.

SELECTED OPTIONS FOR THE OPTIMIZATION OF THE HV NETWORK FROM THE POINT OF VIEW OF CONNECTING LARGE LOADS

Jan Hejhal, Zbyněk Brettschneider, PREdistribuce, a.s., Petr Skala, EGÚ Brno, a.s.

The area of network optimization modeling with emphasis on applicability in practice is an important direction today also with regard to the current energy situation, where the demand for connecting large point loads (in the order of units and tens of MW) at the HV level is increasing.

This paper deals with the design of the optimization of the HV network when connecting large point loads in terms of their power capabilities. In general, the options for connecting a new large load are its: i) connection to an existing line without further modifications, ii) connection to an existing line with its relief consisting in moving a suitable existing switching station to another nearby line, iii) connection by a new line of the power network. The maximum load on the existing lines, the existing reserved power and capacity on the lines and the condition of the surrounding substations in terms of available vaults shall be taken into account. The paper focuses on the analysis of the potential of the first two options within the whole distribution area, while the analysis verifies the possibility of connection or reconnection with a check on variant loads (over reserved power, maximum annual load on the lines) and the fulfilment of the N-1 criterion. The output is a set of recommendations for connecting large loads in the urban 22 kV cable supply network.

ROLL-OUT OF SMART METERS WITH NB-IOT/LTE CAT M - PRAKTICE EXPERIENCES

Petr Mlýnek, Pavel Mašek, Radek Fujdiak, Ján Sláčik, VUT v Brně

The paper presents experiences from the deployment of wireless technologies suitable for smart metering and selective planting. The theoretical assumptions of the technologies were verified by real measurements in selected locations with borderline signal levels, i.e. "deep indoors".

SMART STATION 2.0

M. Šolle, J. Martínek, M. Mráček, J. Voňka, PREdistribuce, a.s.

Since the launch of the roll-out of smart distribution stations in 2019, PREdistribuce has operated more than 300 of them to date. The experience with implementation, testing and operation itself has on the one hand confirmed the correctness of the principles underlying the smart station concept; on the other hand it has provided several suggestions for its innovation. New requirements, such as the control of production modules above 100kW or a higher level of station security, were added. As a consequence, a concept labelled "Smart Station 2.0" was launched this year, which is the focus of this paper.

EVALUATION OF THE QUALITY OF ELECTRICITY SUPPLY FOR 2021

Jan Liška, Energetický regulační úřad

The paper deals with the evaluation of the quality of electricity supply and related services in the Czech electricity sector for the year 2021. The main focus is on the evaluation of the achieved level of continuity indicators, including the link to the incentive regulation of quality. The paper includes an update on the upcoming data collection on short-term interruptions. This information will be used to calculate the MAIFI indicator, the monitoring of which the Energy Regulatory Authority plans to introduce.

SYSTEM SUPPORT FOR EE SUPPLY RESTORATION IN CASE OF MV CUMULATIVE OUTAGES

Marián Veselka, Mária Nováková, Tomáš Škumát, Západoslovenská distribučná a.s., Petr Skala, EGÚ Brno, a.s.

The paper describes the process of preparation and implementation of a system tool for dispatching control personnel to support optimization of restoration of EE supply to customers in case of accumulation of HV faults. The tool is implemented directly in the SCADA system and interacts with the SCADA SRI module (Incident Management System). The system works over the current status of the distribution network. It takes into account the action of protections, information from short circuit current crossing indicators, current availability of remotely controlled elements, network load, fault type and customer counts. The result is a design of handling steps by remotely controllable elements of the distribution network, which will allow to locate the affected section of the network and to restore distribution, to as many customers as possible and in the shortest possible time.

THE IMPACT OF CALAMITIES ON DISTRIBUTION CONTINUITY PARAMETERS AND THE FREQUENCY OF VOLTAGE DROPS IN THE DISTRIBUTION NETWORK

Miloslava Tesařová, ZČU v Plzni, FEL – KEE, Martin Kašpírek, EG.D, a.s.

The paper presents the impact of calamities (cumulative disturbances recognized by ERO) in 2021 on the distribution continuity parameters of SAIDI and SAIFI, both in terms of overall system indicators and indicators for the Q-component. The accumulation of disturbances due to adverse (mainly weather) conditions affects not only the number of long-term interruptions (entering into the SAIDI and SAIFI assessment), but also the number of short-term interruptions (entering into the MAIFI assessment), respectively resulting in an increased incidence of voltage sags. The results of the measurements and the impact of the selected calamities on the frequency of short-term interruptions or voltage sags are then demonstrated on a sample of the EG.D distribution network with permanently installed PQ analyzers in relation to the average annual frequency of these types of events. The correlation between long-term interruptions, short-term interruptions and voltage sags are also dealt with, where no clear rules have been established for the separate assessment of these phenomena.

SESSION 6: MANAGEMENT, ORGANIZATION, QUALIFICATION

Garant: Martin Schneider, PREměření, a.s.

PREDI'S DISTRIBUTION NETWORK IN THE CONTEXT OF TRENDS IN THE ENERGY SECTOR, THE DEVELOPMENT OF SOCIETY AND THE EVOLUTION OF THE GEOPOLITICAL SITUATION

Martin Hejhal, Kristýna Závorová, PREdistribuce, a.s.

The development of the Prague agglomeration brings with it increasing demands on the distribution system. For the purposes of strategic planning, an analysis of the external influences and trends that have a potential impact on the electricity sector and whose onset can be expected in the next 30 years has been carried out, although many of these factors are (or were) still in their infancy. In the context of the invasion of the territory of Ukraine by the Russian Federation and the resulting deterioration of the energy situation in Europe, some trends have become much more urgent and pressing than could have been anticipated at the time of the "pre-war" launch of the analyses. This paper summarizes the most important insights and results of the trend analyses that have the potential to affect the electricity sector not only in the following winter 2022/2023, but also in the next 3 decades.

THE ADVENT OF COMMUNITY AND INDUSTRIAL ENERGY

Hynek Beran Václav Slánský, Cygni, s.r.o. a CIIRC ČVUT

The electricity system of the Czech Republic was created by the integration of industrial power plants and electricity associations already during the First Republic. At that time, hundreds of power cooperatives already existed, with consumers, especially in rural areas, sharing power plants. Nowadays, there is a lot of talk about community energy and few people realise that it is not a completely new concept. A practical example of a town with its own heat network will be used to show the practical applications that such a community structure is capable of, as well as the possibilities for flexible energy consumption and supply.

THE POTENTIAL OF PLC COMMUNICATION FOR SMART METERING

L. Karlovský, P. Glac, J. Poslušný, PREdistribuce, a.s.

The use of PLC communication in urban buildings seems to be a promising way of data transfer between meters and the master system for technical and economic reasons. In addition to the expected benefits, certain limitations must be taken into account and respected.

On the basis of the defined functionalities of AMM and the related communication requirements, a concept for the deployment of this technology in the PREdistribution network has been prepared, which is the focus of this paper. This includes in particular the selection of suitable sites and objects, the logic of the placement of PLC concentrators in relation to the topology of the distribution network, interference measurement and traffic monitoring. A comprehensive approach to the verification of the suitability of the use of PLC communication is also addressed in a project supported by TAČR, implemented in cooperation with CTU.

HOW TO SAFELY APPROACH THE FLEXIBILITY OF ACTIVE CUSTOMERS

Ivan Trup, MicroStep - HDO s. r. o.

The energy sector and the economy are experiencing turbulent times. Rising energy prices are forcing all market participants to seek solutions to reduce the negative impacts of both inflation and non-inflationary energy price rises. We are looking for ways to increase capacities for connecting RES. We know that we are facing a shortage of regulated energy. Aggregating flexibility provides a common solution for providing regulating energy and at the same time increasing the capacity to connect RES. The active customer is no longer just a tariff-blocked household. What are the expectations for a solution to engage active end-customers in the future flexibility market in a way that does not compromise the security of electricity distribution? Let us look at the process of providing flexibility from the perspective of the active customer. We don't have to wait for the perfect solution. We can put together a pragmatic solution for aggregating flexibility at the LV level today.

PROJECT DECODIS - SOLUTION FOR DECENTRALISED CONTROL OF DISTRIBUTION NETWORK (DS) OPERATION DURING THE TRANSITION FROM HDO TO AMM

A. Mikula ZPA, F. Procházka MycroftMind, O. Mamula ČVUT, P. Mlýnek VUT, M. Střelec ZČU, F. Kasl MU CERIT

A new generation of smartmeter with adaptive analytical functions based on artificial intelligence methods will allow the application of predictive models in planning and controlling DS operation without increased data transfer requirements. Improved network observability is the basis for optimizing network operations. Predictors use full knowledge of the distribution network context (e.g. topology, etc.) but can also work with incomplete contextual information.

The extension of communication capabilities with other devices downstream of the meter (e.g. CHPs, charging stations) and the deployment of an enhanced local control component (Smart Box) will further support the systematic transition from the existing control system to a flexible system capable of taking advantage of the penetration of new technologies into the DS and taking into account the influence of new stakeholders implementing technical, social or market-based services.

DATA-DRIVEN MODELING OF CONSUMER POINTS ON AMM BASIS

M. Střelec ZČU, J. Louda ZČU, O. Mamula ČVUT, T. Pitner MU CERIT, F. Kasl MU CERIT

The subject of the paper is to present the methodology and practical implementation of modelling the consumption behavior of a group of OM from continuous measurements. The basic categorization of OM can be used to define individual groups of consumption points (e.g. by tariff, breaker size, etc.). By appropriate processing of continuous measurements and based on cluster analysis, groups of OM with similar behavioral patterns (so-called clusters) can be found for which high quality simulation and prediction data-driven models can be built by applying machine learning methods to the measured data. The methodological steps leading to full-fledged data-driven models of groups of OMs are shown using real measurements obtained from smart meters, whose accuracy is further discussed in the context of relevant TDDs. It is shown that with baseline measurements from smart meters, a small number of groups of homogeneous OM behaviors can be identified for which significantly more accurate data-driven models can be constructed than those provided by currently used TDD methodologies.

DIGITALIZATION OF DISTRIBUTION NETWORK ELEMENTS

V. Šimončík, PREdistribuce, a.s.

As part of innovation activities, two projects were launched to digitize elements of the distribution network. The first one concerns the panoramic photo documentation of the interiors and technologies of distribution substations with the planned use of this data by maintenance staff, or by construction engineers or designers in case of planned renovation. The second project concerns the pass porting of connection points and meter boxes. Its main objective is to prepare for the future rollout of AMM. The paper presents the procedures, the scope of the data and its future use.

PLATFORMA PRO UNIVERZÁLNÍ ANALYTIKU - BEST PRACTICES

P. Lžičař, Awesense Inc

Distribution companies face a large number of challenges on a daily basis, the solution to which lies in processing the large amount of data they produce. Challenges such as renewable connectivity, e-mobility, customer satisfaction, network planning and asset management are just a subset of the areas where data analytics plays an important role. While data analytics is not a new concept for distribution companies, designing and implementing a universal analytics platform is not a simple process. Distribution companies must overcome a number of barriers to this implementation, the complexity of which can be significant. Awesense presents best practices for the implementation and functionality of a universal analytics platform that supports a wide variety of use cases.

PROVISION OF SVR SERVICES AND DISPATCHING

Jindřich Zoubek, TECHSYS - HW a SW, a.s.

The new version of the 2021 CEPS Transmission System Code and its latest update of 1 April 2022 opened new opportunities for other electricity market participants to participate in the so-called power balance services (PBS) and thus participate in the economic evaluation of their investments in resources and help to stabilize our electricity system by providing energy using so-called aggregation units using resource flexibility. This new opportunity is also a further incentive to decentralize, i.e. to further build smaller decentralized sources, especially RES. The paper briefly discusses both the actual issue of SVR and the technical treatment and advantages of the TECHSYS solution.

ACCUMULATION POSSIBILITIES IN CONNECTION WITH THE DEVELOPMENT OF E-MOBILITY

Martin Schneider PREm, a.s.

The gradual development of EVs is beginning to have an impact on the transmission capabilities of the grid. This paper deals with the storage capacity of electric vehicles. Is it now meaningful to address not only the potential impacts of recharging but also the controlled discharge of EVs? What are the possibilities of using batteries in EVs.