HRVATSKI OGRANAK MEĐUNARODNE
ELEKTRODISTRIBUCIJSKE KONFERENCIJE - HO CIRED
5. (11.) savjetovanje, Osijek, 15. - 18. svibnja 2016

SO5 - 13

František Vybiralik
CK CIRED
Email vybiralifra@gmail.com

Linda Vankova Vybiralikova
ČEZ, a.s.
Email lowdrive@seznam.cz

PLANIRANJE I POGON NAPREDNIH DISTRIBUCIJSKIH MREŽA

SAŽETAK

Prilikom rekonstrukcije odnosno izgradnje distribucijskih mreža susrećemo se velikom brojem tehnoloških noviteta. Među najznačajnije činjenice suvremene energetike spadaju razvoj obnovljivih izvora, distribuirane proizvodnje električne energije, postrojenja za skladištenje električne energije, uređaja za regulaciju napona te infrastrukture za punjenje električnih vozila. Osim toga, u postupku traženja optimalnih rješenja uključujući i stabilnost pogona mreže pojavljuje se kao novi element potreba za integracijom i obradom rezultata pogonskih mjerenja.

Analiza opisanih utjecaja i praktične preporuke za budućnost temelje se na rezultatima odabranih pilot projekata, uz uvažavanje ekonomskog aspekta cjelovitog rješenja.

Ključne riječi: distribuirana proizvodnja energije, distribucijske mreže, regulacija napona, infrastruktura za električna vozila, pogonska mjerenja

PLANNING AND OPERATING NEW DISTRIBUTION SMART GRIDS

SUMMARY

The current distribution grids infrastructure reconstruction and development is accompanied by number of the new technological trends. Among the most important issues of the present-days power engineering belong development of the renewable resources, distributed energy generation, facilities for the energy accumulation, voltage regulation, and charging infrastructure for electro vehicles. The new element within the process of the search for optimal solution and network stability is the integration of the operational metering including relevant data processing.

Analysis of this contribution and practical recommendations are based on the results of the selected pilot projects with the respect to economy of the complete solution.

Key words: distributed energy generation, distribution grids, voltage regulation, infrastructure for electro vehicles, operational metering

1. INTRODUCTION

A new generation of intelligent network with higher added value and are defined as Smart Grids. The development of Smart Grids is influenced by new directions in the distribution networks, in particular:

- connecting large amounts of renewable energy sources,
- the requirements for the network stability and voltage regulation
- energy storage system
- compliance with the requirements of power quality
- integration of business and operational measurement of electric energy.

Development of these new directions opens discussion on centralized and decentralized model of power engineering development, in particular in new technologies.

2. THE RES INTEGRATION INTO DISTRIBUTION NETWORK

The economic costs and technical feasibility studies increase the interest of suppliers to link commercial and technical measurements wherever it is possible to reduce investment and operating costs. The integration of commercial and operational measurement must meet a variety of requirements and assumptions, to be effective and acceptable. Between the basic assumptions include the implementation of the open standard data protocols, independent of communication channels and the security of data transmissions.

Among the required parameters for the integrated instruments include a prescribed number of inputs and outputs, modules, measuring the power quality and the special requirements of the customer. All these requirements have an impact on investment and operating costs of equipment.

At planning and construction of new networks, it is necessary to take into consideration the energy model, centralized or decentralized with regard to effectiveness and technical feasibility.

Uncontrolled connection of the small power sources and unlimited development of larger dispersed sources may result in a highly unstable network condition and reduces reliability of electric energy supply for all customers. In the future the situation may get worse, if arrive at high development of e-mobility. Implementation and development of e-mobility, will accompany the construction of rechargeable infrastructure for electric cars, and it will require a significant strengthening of the distribution networks, which will require high costs. One of the options for solutions of the voltage regulation problem and reducing the cost of strengthening the networks are electrical energy storage systems.

3. CONSTRUCTION OF NEW GENERATION NETWORKS

The development of renewable energy sources and dispersed generation is the main criterion for building Smart Grids. RES in many countries obtain significant political backing and economic incentives. RES become part of the energy mix [2].

The energy security of the state has two basic aspects. On the one hand, it's the security of fuels and energy supply, and on the other hand the operating safety. The development of RES can contribute to energy and fuel the country's independence, but their impact on operational security has a rather negative site. Subject to considerations of operational safety are not only unstable sources type of photovoltaic power plants, wind power plants, but also biogas sources and biomass resources, which are scattered throughout the territory of the state. The dispersal of distributed generation as now poses a risk from the perspective of the entire system, which must count to ensuring the reliable operation of the system. Another problem RES, distributed generation and energy storage systems are the requirements for connectivity, the parameters of the inverters, the quality of electricity supply.

Connecting RES to the low-voltage networks is an essential issue for the development and operation of these networks. These networks are not designed for two-way power flow. Long-term monitoring of the status of the networks shows the negative impact of dispersed generation, especially RES on the stability of the network. Special attention must be paid to the quality of the supply voltage, but

also the supply of electrical energy and the requirements to ensure the required electrical power and energy.

The basic requirement, which is placed on the distribution company, is to provide voltage quality according to the applicable regulations and standards (EN 50 160, EN 61000-4-x).

According to the sources, and the operators of distribution networks is an important to work with active power and reactive power control. At the same time it is necessary to ensure a balance of production and consumption of RES in the distribution network.

The requirement for the stability of the network should comply with the new design, which will cover the requirements for the planning of production and consumption of electric energy. This solution should include selected kinds of RES, in particular photovoltaic and wind power. The overall design must address the new requirements of the management, protection and security of networks, including the possibility of accumulation of electrical energy.

These newly designed systems can be also the central point of the integration of the business and operational measurements, including monitoring the health of the network and the new concept of supervision and control. The current systems of the EMS (Energy Management Systems) already integrate modules for weather forecasts and the resulting production planning and the unavailability of energy sources, especially solar and wind power plants. Modeling the operation of dispersed sources becomes an integral part of the monitoring and control of distribution networks. The concept of building MicroGrids must address the operational issues related to the new power balance as part of the solution to Smart Grids.

3.1. NETWORK MONITORING AND CONTROL

Network monitoring and control represents a wide range of issues. The basis of this task is detailed knowledge of the network and the corresponding methodology of measurement. Among the basic data needed for the assessment of conditions in the network, network simulations and calculations include:

- topology and configuration of the distribution network
- primary line parameters:
  - line resistance
  - line inductance
  - line capacity
  - line lead
- secondary line parameters:
  - transmission constant
  - characteristic impedance
  - parameters of the connected sources of electrical energy
  - quality measurement of the electrical pošer supply

The development of RES will be instability in the production of electricity and reduced the quality of electricity supply. It will therefore be necessary to develop the concept of accumulation of electrical energy. The possibilities for development of storage technologies are the following:

- large storage configuration with capacity 0,5 MW, which will allow the elimination of deviations for traders with electricity and network frequency regulation
- small storage configuration from 3 to 10 kWh for small photovoltaic power plants operators
- batteries in electric vehicles and recharging infrastructure

4. THE REQUIREMENTS OF THE OPERATORS OF THE DISTRIBUTION AND TRANSMISSION NETWORKS

Activities of network operators focuses mainly on the effective operation of the network infrastructure, and in accordance with the applicable rules and legislation for the regulated area of energy. Basically it means to ensure optimal networks operation with the lowest possible costs. For this reason, the evaluation of the price/performance ratio, as well as in the area of measuring the quality of an open question, especially with regard to the monitored parameters, duration of their storage on a device or in a central system and method of evaluation.

Answers to these questions fundamentally affect how the acquisition and operating costs of the measurement reports, communications and data systems, i.e. CAPEX and OPEX. For manufacturers and suppliers of equipment and technology that means to watch all three areas on the basis of the evaluation and further development of the present corresponding solutions. At the same time, most of the vendors trying to actively influence their customers individual Commission organisation for standardisation CENELEC (European Committee for Electotechnical Standardization) and influence legislation in the relevant country.

Regardless of the final design and the functionality represented by the device you will need to a greater or lesser extent, take into account the requirements of the relevant norms and standards. In the case of the measurement of the quality of the electrical power supply is appropriate, and in some cases necessary, based on the following standards for this area, i.e. in particular, EN50160 and IEC6100-4-30 [1, 2]. Based on the above requirements, it is possible to define the key parameters of voltage and current that is suitable to measure, monitor, and process to the required analysis of the status of the network.

It is important also to emphasize that the above revision standard EN50160 are reflected in the new version of related standards such as IEC61000-4-30. This process very frequent changes in requirements, at the same time raises the uncertainty on both sides the producers and network operators, which direction will this area to develop. In this direction would be the specific guideline may be already documented the results of the impacts of the distributed production of electric energy, in particular RES, the development of the state and the networks characteristics.

Among the most serious issues from the perspective of existing networks and resources include in particular the imbalance between production and consumption of electricity, the frequency of the supply voltage, overvoltage, harmonic distortion and voltage and current asymmetriesy. In general, we can conclude that the operation of RES causes significant fluctuations in the network frequencies and overvoltages that go beyond the prescribed standards. An example might be EN 50160 when voltage deviation shall not exceed 253 V i.e., the value of the 110% Un.

4.1. WAMS/WAMPAC

The issue of monitoring, measurement and management today enters the next phenomenon in the form of systems of WAMS/WAMPAC (Wide Area Monitoring System/Wide Area Monitoring, Protection & Control). An essential element of these systems is installation the units PMU (Phasor Measurement Unit) measuring synchronous phasors at selected places on the network, i.e. in the network nodes, in addition to conventional measurement. These units should then correspond to the international standard IEEE C 37.118: 2005.

Among the basic PMU functionality shall include in particular a comprehensive monitoring of the node voltages, currents, phase angles, line temperature and current transmission line capacity (Dynamic Rating) i.e. ampacity, the frequency of the oscillation system including the analysis, etc. In general, so the key characteristics include the monitoring of the stability of voltage detecting system oscillations, prediction of critical operational and system states and prevent accidental situations.

Equally important, is also a simulation system covering the electromagnetic transient phenomena and electromechanical dynamics analysis system. The intention is to enhance the operational safety of the system and reduce the number and duration of outages.

WAMS/WAMPAC solutions are not a completely new technology, development was launched more than 15 years ago, the ambition to affect the area of development an operational measure and protected are obvious.

The analyze of the different ways and methods of control of frequency and voltage, which mainly includes the following tools and resources, respectively their combination of:

- network architecture and solutions based on a combination of accumulation with reserve dynamic source
- regulatory DTR with regulation options under load
- regulation of voltage and frequency with the use of storage system
- dynamic load control on the level of the substation 110/22 kV
- The regulation of reactive power for power plants connected to voltage levels 22 kV

Voltage/current asymmetries arise especially due to improper connection of sources, appliances, when there is an imbalance of three phase load. Of course, it is necessary to emphasize, that the large current asymmetry causes voltage imbalance. In principle, we're talking about the state, when the phase angles are 120°.

A model of distributed generation, however, faces further obstacles such as in the form of installed converters that offer the parameters of short-circuit currents above the level of the maximum rated current. Another complaint is the short-circuit power solutions and the corresponding parameters of the distribution and transmission networks, which practically displacing classic rotary resources with negative impacts to operation, frequency and voltage characteristics.

Most advocates of the distributed model with a high proportion of RES acknowledges that the planning and construction of new networks is a complicated and long-term issue. From the perspective of the next period and the medium-term perspective it is important to perform own measurement of networks parameters, in particular as regards the minimum short-circuit impedance before connecting the renewable energy source.

The basic premise of successful network monitoring is a dedicated event in the respective registers, in particular as regards the number of events with time indication, duration and classifications. Thus established gives an overview of the distribution companies, the ability to track and calculate basic indicators of reliability of supply, such as index SAIDI (System Average Interruption Duration Index), SAIFI on (System Average Interruption Frequency Index), and CAIDI (Customer Average Interruption Duration Index).

Loading the Smart Metering in accordance with EU directives 2009/72/EC and 2012/72/EC presently, taking into account the opinion of the Government of the Czech Republic is suspended. One of the reasons is the efficiency and cost of the required solutions. These measures remain still valid, and most of the EU countries, counts with the implementation of intelligent metering. Among the key parameters of the Smart Metering belong the following:

- monitoring of balance sheets, technical and non-technical losses and their reduction,
- implementation of sophisticated solutions related to regulation, disconnecting customers and their migration between energy suppliers.

The development of intelligent measurement within the concept of Smart Grids must continue to take into account the efficiency of investments and their return to their own measuring techniques, communications infrastructure and system solutions, including the costs of the operation. The concept of Multi-Energy offers a unique technological and economic advantages in comparison to the separate operation of the intelligent measurement and control in the segment of measuring of electricity, gas, water and heat. Among the key advantages include:

- common telecomunication infrastructure and related savings
- common system solution reading and control of measuring reports

4.2. CURRENT SITUATION IN THE CZECH REPUBLIC

In the Czech Republic, there are a number of legislative, organizational and technical barriers that need to be solved as part of a serious analysis of the whole issue. The indisputable fact remains a different development of the liberalization and deregulation of the market in countries where today is the concept of Multi-Energy implemented, such as the United Kingdom and the Netherlands, in comparison with the Czech Republic. A key aspect in addition to ownership of large energy groups in these countries is the emergence of service companies that can own a billing meter including the entire measurement infrastructure. Service companies then provide all service and maintenance of the gauges, data processing of measurement, including the final billing. This assumption in the conditions of the Czech energy market is not fulfilled.

5. SMART REGION – THE PILOT PROJECT OF ČEZ

For the implementation of the pilot project was selected, the part of the town of Vrchlabi, in the North East of the Czech Republic. The selected part is called the Liščí kopec “Fox Hill” and includes about 30 residential houses, a primary school and about 50 family houses. The total AC power capacity is about 1.2 MW.

In the framework of the project has been refurbished medium-voltage network and 16 transformation stations. On the edge of the site is the heating plant, which supplies heat to this settlement. In the heating plant was installed a cogeneration unit of 1.6 MW power, which supplies power to a medium voltage network and enables network operation in island mode.

The trial test has been successfully tested parallel operation with the distribution network and the island operation and the transition from one mode to another. In the low-voltage network were tested the new elements. In the fuse boxes were installed circuit breakers with variable characteristics.

Fig. 1 – New transformation station MV/LV for Smart Region

6. CONCLUSIONI

On the basis of the analysis, it is possible to unambiguously state that today's developments in the field of power engineering is the changes that we in this conservative branch in the previous history, and especially in the last 100 years, hardly looking for. Successful implementation and deployment of technologies and related solutions in construction of energy sources and networks will require careful analysis of the current development, status of the network and the search for appropriate solutions.

The basic prerequisite for the successful implementation of new management approaches and solutions with regard to their economy and the rate of return is system integration with existing technology and provide the required functionality, which will have to ensure the same user standard so far, if not better.

Due to the fact that some EU countries have already issued by way of the massive support and development of RES and distributed generation of power, the Czech Republic may draw from their experience. At the same time it is very likely that the energy concept of the Czech Republic will promote other energy and economic model of development of power engineering, the representation of individual energy sources in the energy mix and the development of the network infrastructure.

REFERENCE

[1] ČSN EN 50 160, Czech version of European standard EN 50 160
[2] Mastny P., Drapela J., Renewable energy source, CVUT Prague, 2011
[3] Directive 2012/27/EU of the European Parliament and of the Council of 25. October 2012
[4] Dolara A., Leva S., Power Quality and Harmonics Analysis of End Users Devices, Energis 2012
[5] Hladik M., Intelligent Networks and New generation Measuring, Energetika, 2014