Smart grids and their impact on the distribution system

[1]*Maksym Oliinyk (2nd year)*
Supervisor: [2]Jaroslav Džmura

[1,2]Dept. of Electric Power Engineering, FEI TU of Košice, Slovak Republic

[1]maksym.oliinyk@tuke.sk, [2]jaroslav.dzmura@tuke.sk

***Abstract*—the concept of smart grids is used to refer to a group of technologies that work together to create a next-generation network. The use of individual components of a smart grid can not only reduce efficiency, but also disrupt the normal functioning of the distribution network. For this reason, a complete solution is needed, which will include individual elements, communication, and monitoring and control systems.**

***Keywords*— smart grid, electric vehicle charging, microgrid, renewable energy sources.**

I. Introduction

The energy system based on the Smart Grid concept is a single energy-information complex where managed objects must allow remote control. Systems for assessing the situation and emergency automation - to reduce excessive requirements for reserves of power and information capacities. [1] The appearance of such a system is an opportunity, due to new technologies and a new control system, to radically change the principles of functioning of the electric network. As part of the transition from classical networks to new generation networks, the European Union has identified the following important areas of development [2]:

1. Intelligent network management.
2. Demand Management (DSM).
3. Integrated production and storage (DG&S).
4. Electric transport.
5. Broad integration of renewable energy sources.

Although the theoretical upgrade of the network is simple, the deployment of an intelligent network is a complex technical process. Consequently, the success of a smart network will require a comprehensive multidisciplinary understanding of the various technologies whose activities must be coordinated to ensure its successful, efficient and safe operation. In regions where the implementation of smart grids has already been partially implemented, economic benefits are shown. Such solutions for the modernization of the electric network reduce energy bills for consumers; the installation of batteries improved uninterrupted power supply for critical loads, improved energy quality and reduced the number of accidents [1].

In my research for the first year, I focused on how various technologies have an impact on modern networks, as well as on methods for solving them. Therefore, besides the problem of inconsistency in the production of electric energy, there are other features of the functioning of renewable energy sources that affect the functioning of the energy system, which were investigated in several scientific articles. Some of them are listed below:

1. The installation of a large number of renewable energy sources, has led to such a thing as a negative price for electricity. It is increasingly found in countries with large installed capacity of renewable energy sources. Therefore, in Germany for the first week of February, the price went into the negative zone 4 times fig.1 [3].

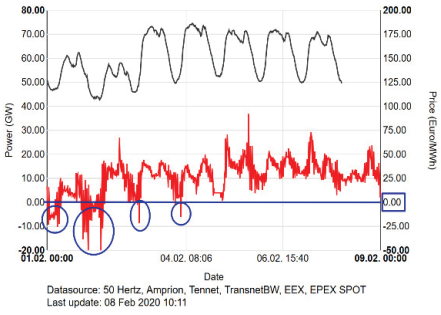

Fig. 1. Price changes in Germany due to high generation in renewable energy sources [3]

2. Installation of a large number of renewable energy sources with insufficient battery capacity in low voltage networks causes an increase in electric power losses during transmission because of the so-called reverse power flow fig. 2[4].

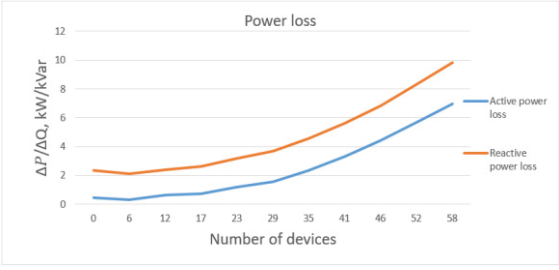

Fig. 2. Changes of active and reactive power loss [4]

3. Installation of a large number of renewable energy sources in low voltage networks causes an increase in voltage in individual sections of the network, sometimes exceeding the permissible limits fig3 [5].

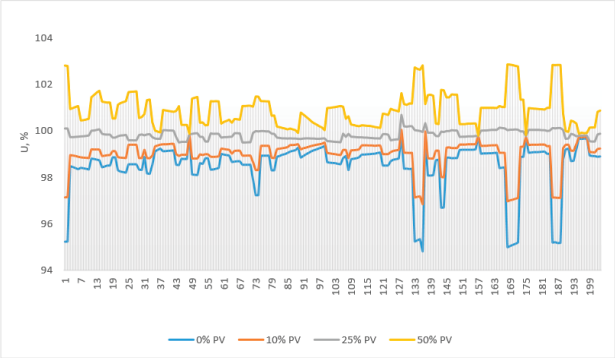

Fig. 3. Change in voltage in network sections with an increase in solar panels [5]

4. The installation of a large number of renewable energy sources in low voltage networks causes an increase in short circuit currents fig 4. [4].

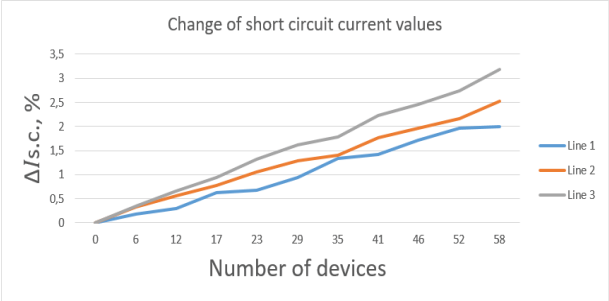

Fig. 4. Changes in short-circuit currents depending on the number of connected photovoltaics [4].

In recent years, there has been a clear trend in the automotive industry towards a shift from classic cars with an internal combustion engine to electric cars. That is, in the coming years, more and more cars with zero emissions of harmful substances will begin to appear on the roads, which, according to forecasts, should eventually completely displace classic cars [6]. Several scientific articles have investigated how widespread use of electric vehicles will impact the functioning of classic networks. From the conclusions of the studies, the following conclusions can be drawn [7]:

1. Modern networks are technically able to withstand the use of electrical machines up to 35% of the total [7].

2. When using electric machines for 15% of the total, it increases losses in the electric network by 100%, and when using 35%, the losses increase by 330% [7].

Most of the above problems can be solved by installing energy storage systems of different capacities. In addition to improving the physical performance of the network (reducing currents in lines, reducing power losses during transmission, keeping voltage within acceptable limits) fig 5[7].

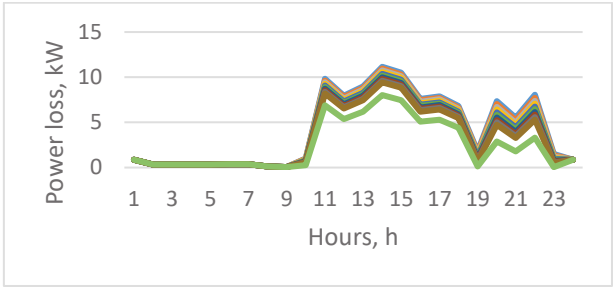

Fig. 5. The dependence of active power losses when using storage systems with a capacity of 10-100 and 180 kW [7]

It is possible to use negative electricity prices for so-called price arbitration (when prices are near zero or in the negative zone to buy electricity and store in batteries, and sell during peak hours, when the cost is maximum). With lower battery costs, this will open up additional opportunities for distribution companies.

At the moment, we can conclude that for the full operation of networks based on the concept of Smart Networks, an integrated approach to the use of a group of technologies is required, as well as the creation of a management system for them. In my further studies, I plan to focus on various control systems. Which can be grouped into several groups:

- management on the consumer side,
- charge management for electric vehicles,
- management of electric energy storage systems,
- voltage control using solar panel systems (inverter + solar panels)

ACKNOWLEDGMENT

This work was supported by the Scientific Grant Agency of the Ministry of Education of Slovak Republic and the Slovak Academy of Sciences by the projects VEGA No. 1/0372/18.

REFERENCES

[1] N. Nikmehr, S. N. Ravadanegh, "Optimal power dispatch of multimicrogrids at future smart distribution grids," IEEE Transactions on Smart Grid, 2015, pp. 1648–1657.

[2] Anna Mengolini, "Smart grid projects outlook 2017", Luxembourg, 2017, ISSN 1018-5593 Available on internet: <https://ses.jrc.ec.europa.eu/sites/ses.jrc.ec.europa.eu/files/u24/2017/sgp_outlook_2017-online.pdf>

[3] Prices on electricity in Germany, Available on internet: < https://energy-charts.de/index.htm>

[4] Zsolt Čonka, Maksym Oliinyk, ...[et all], „The Impact of a Low-voltage Smart Grid on the Distribution System", in EPE 2019 : Proceedings of the 20th International Scientific Conference on Electric Power Engineering. - Ostrava (Česko) : Vysoká škola báňská – Technická univerzita Ostrava s. 1-5 [USB-key]. - ISBN 978-1-7281-1333-3

[5] Maksym Oliinyk, Michal Kolcun, Michal Ivančák, „Inteligentné siete", in Electrical Engineering and Informatics 9 : proceedings of the Faculty of Electrical Engineering and Informatics of the Technical University of Košice. - Košice : FEI TU, 2018 S. 283-288. - ISBN 978-80-553-2713-6

[6] Global EV Outlook 2019, Available on internet: <https://webstore.iea.org/global-ev-outlook-2019>

[7] Maksym Oliinyk, Jaroslav Džmura, "Power loss in smart grids" in: Elektroenergetika 2019: Proceedings of the 10th International Scientific Symposium on Electrical Power Engineering. - Košice (Slovensko) : Technická univerzita v Košiciach 541-545 [CD-ROM]. - ISBN 978-80-553-3324-3