The Challenges Facing the Electricity Transmission System Dictated by the Goals of the Green Transition

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***Abstract*—The report analyzes and systematizes the challenges facing the power transmission system dictated by the goals of the green transition, as well as the impact of the development of renewable energy sources on the need to develop the power system.**

Keywords*— *renewable sources, low-carbon energy, electricity system, styling, insert (*key words*)

I. Introduction (*Heading 1*)

In fulfillment of the goals of transitioning to a low-carbon , secure and competitive economy at the end of 2018, the European Parliament adopted new goals for the use of renewable energy sources and energy efficiency. By 2030, the energy efficiency of the European Union (EU) must improve to at least 32.5%, while the share of energy from renewable sources (RE) must be at least 32% of the EU's final energy consumption. Renewable energy sources are hydropower, wind energy, solar photovoltaic energy, solar thermal energy, geothermal energy, solid biofuels, charcoal, biogas, landfill renewable waste, liquid biofuels and ambient heat. For the implementation of the goals and management of the Energy Union, the EU member states are developing a 10-year plan for "integration of national energy and climate" with national goals, contributions, policies and measures. The project for the "Integrated plan in the field of energy and climate of the Republic of Bulgaria" for the period until 2030 [1] defines the policies and measures for the production and consumption of energy from renewable sources and sets the following goals: the share of renewable energy (RE) in the gross final energy consumption to reach 16% in 2021, and by 2030 - 25%.

II. Description of the problem

In recent years, a significant growth of renewable energy has been observed in Bulgaria. The primary production of renewable energy in 2017 was 1,938,000 tons of oil equivalent (so) , the amount increased by a total of 90.1 % , or 1.9 times compared to 2007. This represents an average increase of 7.1 % per year. The production of primary energy from renewable sources in the country is ahead of the overall growth rate in the EU-28. In 2017, Member States increased production by 65.6% compared to 2007, or an annual average of 5.2%.

A main strategic goal for the development of the energy sector is the reliable provision of clean and affordable energy for all users [2]. This can be achieved by:

- Guaranteeing energy security in the country and the region and affirming the role of Bulgaria as an energy pivot;
- Sustainable use of local energy resources;
- decarbonisation targets;
- Increasing energy efficiency;
- Ensuring a just transition of affected areas.

The sustainable transformation to low-carbon energy requires a long-term strategy, predictability and phasing without putting the systemic adequacy of the country's electricity system (EP) at risk. Ensuring the adequacy and security of Bulgaria 's EP, as well as balancing and regulation under the terms of the Green Deal, must be ensured with reliable low-emission technologies that have the availability to ensure electricity consumption and the flexibility to balance. Along with the introduction of electromobility and the development of hydrogen production technologies, there will be a need to increase the share of generating capacities with high availability.

It is necessary to keep in mind that the EP of the Republic of Bulgaria could not rely on basic electricity from the region, but must look for a solution to its energy and national security only at the national level. At the present time, an energy mix of generating sources is available in the EP of the country, in which security and sustainability are mainly provided by the synchronous generators of systemic importance in conventional power plants.

The thermal units described in Reform 10 of the Recovery and Resilience Plan (RRP) have a total installed gross capacity of 4,874 MW, of which 3,648 MW are basic generating capacity and 2,686 MW with the ability to adjust around the clock, use as basic or sub-peak capacities, as well as for the implementation of the following particularly important and mandatory tasks:

- For primary frequency and exchange power regulation within the ENTSO-E Continental Europe synchronous area;
- For participation in the secondary regulation of frequency and exchange capacities of the EP of the Republic of Bulgaria;
- To maintain the voltage levels in the main nodes of the EP;
- To maintain the EP sustainability stock;

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- To maintain the total momentum stock of the EP;
- To participate in the protection plan and the recovery plan of the EP after severe accidents.

Due to structural and technological features, at this stage of the development of science and technology, WPP, PHPP, TPP, small HPP, BioPP and plant thermal power plants cannot provide a reserve for primary frequency regulation, as well as participate in the 24/7 centralized regulation of voltages in the main nodes of the EP. Also, these energy sources cannot participate in the formation of electricity corridors from start-up plants, hindering the stability of the island regimes, which means that the EP will lose its ability to recover through its own generation sources. In contrast to thermal power plants, renewable energy sources give unstable production of electrical energy proportional to the variable primary energy carrier or production of electrical energy in a forced mode.

In order to preserve the energy independence of the Republic of Bulgaria and its role as a net exporter of electricity and a balancer for the region, Ministry of Energy (ME) developed a scenario for electricity development for the period 2023 - 2053 under the following assumptions:

TABLE I.

A sub-industry	Basic assumptions 2023 – 2053
Coal Power	Use of existing capacities until 2030 to ensure energy security
Nuclear Power	Construction of 2 Units of 1,000 MW each at the Belene site by 2035/2040. Construction of 2 Units of 1,000 MW each at the Kozloduy site - 2045. Staged out of 2 Units of 1,000 MW each at the Kozloduy site - 2050/52
RES	Construction of 7,000 MW PHPP & 2,000 MW WPP – 2030; Construction of a Total 12,000 MW PHPP & 2,000 MW WPP – 2050
HPP	Construction of 870 MW of new hydropower plants by 2030; Construction of 1,270 MW by 2050.
Hydrogen	Construction of 1,000 MW electrolysers for the production of 90,000 t /year. – until 2030.
Energy storage systems	Completion of the extension of pumped storage water power plant PSWPP "Chaira" - by 2030; Construction of new PSWPP 1,000 MW – until 2035; Introduction of 600 MW electric battery ii – until 2030; Deployment of 1,500 MW of seasonal storage systems – by 2050.
Development of networks for HV and MV	1,900 km of modernization and construction of new power lines in the transmission network; Digitalization and development of the distribution network.
Electric mobility	Construction of 1,000 pcs. charging stations for the development of technical and charging infrastructure - until 2030.

The analysis of the assumptions in the above table gives reason to consider that there is a priority of low-carbon and RES capacity, hydro and nuclear power until 2050 to maintain security of supply, while phasing out lignite installations in the period 2030 – 2038. This will of course depend on the market levels of the price of CO_2, which is expected to reach +100 €/ t CO_2 by 2030 and 250 €/ t CO_2 by 2050, the process of increasing the price of emissions naturally leads to a reduction of electricity production from coal plants by about 60% by 2030, which is equivalent to a reduction of nearly 55% of emissions for Bulgaria compared to 1990.

The final demand for electricity in Bulgaria is expected to reach around 61 TWh by 2050, representing a doubling of that from 2020. The increased demand for electricity is mainly due to the electrification of transport (electric cars) and the production of green hydrogen through electrolysis.

The dynamics of installed capacities and production in the period until 2053 will develop as follows:

- Coal-fired plants will gradually be replaced in the period 2030-2035 with a combination of RES, HPP and NPP;
- Installed capacity increases by > 20,000 MW by 2050 compared to now. This increase is due to the growth of RES - 16,000 MW, PSWPP&HPP - > 2,000 MW; NPP – 4,000 MW.

As it became clear above, the development of the power transmission network (19,000 km) is planned, which includes the construction of 400 and 110 kV power lines. In the power transmission network development plan, it is noted that the development of a 220 kV network has attenuation functions. This development of the electricity transmission network is related to the construction of about 20,000 MW of new RES. It is necessary to note that the utilization of RES is <25% , as for FEC, it is <20% . This means that in most of the time the newly constructed power lines will be unloaded. This implies the generation of large amounts of reactive capacitive energy and the associated increase in voltages at the EEC nodal points. Therefore, it is necessary to do the following:

- Transverse compensation of the power transmission network with reactors;
- Use of high-temperature wires after a detailed technical and economic analysis.

The integration of renewable sources of electricity using wind and solar as primary energy poses new challenges to the electrical networks of transmission and distribution companies. One of them is the need to transfer high-power flows with a relatively small hourly usability in an annual context (below 2000 hours), and this also determines the low hourly usability of the newly built electricity grids. This necessitates the application of a technical-economic approach when making a decision to increase the transmission capacity of power transmission and distribution lines. In recent years, precisely for these reasons, various variants of high-temperature, low-sag non -insulated conductors have been developed. The report examines various constructions of this type of wire, and compares them.

The commissioning of new generating capacities from renewable sources creates new challenges for the operators of the transmission and distribution networks. The problem with the transfer of large capacities generated by wind power plants (VyaEP) and especially by photovoltaic power plants (PEC) is particularly severe. In this type of generating power, the fluctuation of the generated power varies from 0 to the nominal value in a short time. At the same time, the hourly usability of the installed capacity for hydropower plants is about 2000 hours, and for FEC it is about 1200 hours.

This necessitates the introduction of new requirements to the transmission system, namely: the possibility of overloading - in many cases up to 2 times and more. The increase in the transmission capacity of the 110 kV electrical network can be done either by increasing the cross-section of the non-insulated wires, which leads to the replacement of the existing poles, or by installing those with the same cross-section and weight, but with a higher permissible current load.

Such are the so-called ***high-temperature low- sag conductors*** (*high temperature low sag conductors - HTLS Conductors)* , which will be discussed below.

- ACSR [Aluminum Conductor Steel Reinforced] – standard widespread wire;
- ACSR/AW [Aluminum Conductor with aluminum clad steel cor e] – conductive part made of aluminum, and the supporting part made of special steel with aluminum coating;
- ACSR/TW [Aluminum Conductor with trapezoidal shaped aluminium con d ucting strands] – the conductive part of this type of high-temperature wire is made of trapezoidal elementary wires.

The idea for the creation on high temperature wires everything based on the increase on maximum admissible current through a construction which allows higher current density respectively higher temperatures like mandatory everything keeps sag on the conductor in the mezzanine due to the low one coefficient on linearly extension on the material. The different ones types of VTNPP se differ by construction and used materials. The construction on these wires in most cases everything consists of from two parts - conductive and bearing. Conducted part everything performs or from they retort aluminums or from aluminum alloy providing temperature sustainability on the material. The bearer part everything performs from steel alloy or composite material providing the necessary strength and low linearly extension. Lately everything offers one newer type (AAAC), at which all elementary vein are made from aluminum an alloy which does both _ functions. This one type wires more everything they call homogeneous, and all remained inhomogeneous . I will you are allow Yes systematize the different ones constructions VTNPP in three basic groups in dependence from the carrier stinger :

- base alloy steel;
- special steel ;
- composite core.

The composite ones materials (or composite) are materials which everything consist of basically from hard reinforcing filler (armature) - glass or organic fibers (less often metal threads), and polymeric binders (matrix) - epoxy , polyester and others resinous composed . Through choice on type and quantity armature and matrix can in wide borders Yes everything change the different ones properties on the composite - strength, thermal conductivity, airtightness, relatively weight, chemical sustainability and others. The composites they have for basis ceramics or carbon.

The uninsulated wires filled with carrier sting from composite material they have the following characteristic features: tall strength on tension, modulus on elasticity, vibration resistance, corrosion and acid resistance resistance and low coefficient on linearly expansion, weight and density. Because of the tall ones mechanical indicators on the composite sting is possible the carrier part on the conductor to be with less section. This gives opportunity on the constructors to perform conducted part on the conductor with a larger one section from all remained examined structures – 30%. From his own country this leads to significantly lower electrical resistance, lower electric losses and related emissions of carbon dioxide.

CONCLUSIONS

Bulgaria 's energy system can be decarbonized through continued development of renewable energy sources combined with new flexible low-carbon capacities.

The decarbonization of the Bulgarian energy system leads to an increase in investment costs for production facilities, as well as network costs for transmission and distribution.

In the coming decades, there will be significant changes in the structure of the energy and power mix, which lead to the need to develop the electricity distribution and electricity transmission network of the Republic of Bulgaria. This, in turn, leads to the emergence of new challenges and the formation of management and control concepts in them.

The ultimate goal is for Bulgaria to have a strategy that guarantees the preservation of the energy and national security of the country, sustainable use of local resources and provision of conditions for production, trade and storage of electricity.

The authors would like to thank the Research and Development Sector at the Technical University of Sofia for the financial support.

REFERENCES

[1] January 2019; https://www.me.government.bg/files/useruploads/files/.pdf .

[2] Strategic vision for the development of the electricity sector in the Republic of Bulgaria 2023 - 2053.

[3] Report according to the No. 12HO-819A001/02.07.2012 with NEK EAD " Technical-economic study of the possibilities of applying wires with increased transmission capacity in the electricity transmission network of Bulgaria"

[4] Kolev V., I. Draganova-Zlateva, The development of additional services as a tool for balancing the EEC and the functions of the slow tertiary regulation over the years so far Sp. Energy 2020, no. 7.

[5] M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.