Electricity Grid Modernization in Support of Solar Energy Expansion

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As a mountainous country with a large number of sunny days, the Republic of North Macedonia is an excellent location for investments in photovoltaic power plants. The mountainous terrain allows photovoltaic panels to be installed in areas with lower average annual temperatures, without negatively affecting their exposure to the sun.

The large number of sunny days and lower average temperatures in mountainous regions, are an ideal combination for the operation of photovoltaic panels, because otherwise, increasing temperature disrupts the electrical properties of the semiconductor in photovoltaic cells, i.e. the voltage they generate decreases, and thus the total power of the panel.

Given the aforementioned natural predispositions, and additionally taking into account the liberalization of the electricity market, the development of technology, its increasing availability under commercial conditions, as well as the reduction in the costs of building photovoltaic power plants, it is not surprising that the construction of such capacities in the Republic of North Macedonia is in a real boom.

More specifically, by the end of 2025, the number of photovoltaic power plants had reached a record level. As of 01.10.2025, 517 photovoltaic power plants were registered as a separate category. Additionally, in the category of photovoltaic power plants operating as consumer-producers, 836 connections with a capacity exceeding 40 kW were registered, along with 958 connections with a capacity between 6 kW and 40 kW, and 942 connections with a capacity of 6 kW or less. The Annual Plan for the Construction of Energy Facilities for 2026 envisages the construction of 59 photovoltaic power plants, with a total installed capacity of 3,014.103 MW and an estimated investment value of EUR 2,109,872,100. According to the data from the International Renewable Energy Agency (IRENA), the electricity production from photovoltaic power plants in the Republic of North Macedonia reached 1,058 GWh in 2025, compared to only 17 GWh in 2016.

However, the distribution network, originally designed for one-way distribution of electricity from large traditional producers to consumers, lacks the capacity to fully accommodate the increasingly decentralized system of smaller producers, such as photovoltaic power plants.

In this context, photovoltaic power plants are characterized by variable and difficult to predict production, because the amount of electricity produced directly depends on the weather conditions and the intensity of solar radiation.

Such oscillations in production are reflected in the operation of the distribution network, especially on power flows and voltage conditions. While previously electricity mainly moved in one direction, from the power transformer stations to consumers, with the connection of photovoltaic power plants, a reverse flow of energy can also occur, i.e. from the producers connected to the distribution network back to the power transformer stations. Thus, the points that were previously end-use points, take on a different role, because through them electricity is no longer only taken from the network, but also, at certain periods, electricity is also transferred back to the system. This can cause an increase and variations in voltage, especially in conditions of high production from photovoltaic power plants and low local consumption. Additionally, photovoltaic power plants can also affect the quality of electricity, as the inverters through which they connect to the grid can create voltage and current disturbances, such as harmonics and flicker.

In order to address the above-mentioned problems, namely to increase the capacity and stability of the electricity grid, Elektrodistribucija DOOEL Skopje has adopted the Development Plan of the Electricity Distribution System for the period 2026–2030. It is largely based on a gradual change in the existing voltage structure. Instead of further developing the existing 35 kV, 10 kV and 6 kV voltage levels, which are characteristic of the older configuration of the grid, long-term development is directed towards a grid consisting of three basic voltage levels: 110 kV, 20 kV and 0.4 kV. This means that the 10 kV voltage level will be gradually replaced by the 20 kV voltage level, while the 35 kV voltage level, depending on the needs and characteristics of the specific location, will be replaced by 110 kV or 20 kV voltage level. The transition to higher and more appropriately organized voltage levels enables the distribution of greater electrical power through a more stable network infrastructure, reduces losses, reduces the load on existing lines and substations, and creates more space for connecting new production capacities.

The distribution network investment plan for the period from 2026 to 2030 foresees serious financial investments. The total amount of investments for this five-year period amounts to more than EUR 347.621.400,00. Most of the funds are foreseen in the category of electrical equipment, for which a total of EUR 229.633.700,00 are planned, thereby demonstrating that the main focus of the plan is directed towards directly strengthening the electricity infrastructure. Specifically, a total of EUR 4.519.200.00 are foreseen for high-voltage lines of 35 kV and 110 kV, while EUR 31.665.041,00 are planned for large substations. Additionally, significant funds are directed to the parts of the network that are most directly affected by the connection of new photovoltaic power plants, namely to the medium-voltage network, for which EUR 32.626.016,00 has been allocated, and EUR 45.648.780,00 for upgrades in the low-voltage network.

In addition to investments in the distribution network, planned investments in the transmission network are also of particular importance. Particularly significant is the the construction of a new cross-border transmission line, i.e. the 400 kV interconnecting transmission line Bitola - Elbasan, from the Bitola 2 Transformer Station to the Macedonian-Albanian border, which also includes the construction of a new 400/110 kV Ohrid Transformer Station.

In the further development of the transmission network in the western part of the country, a new 400 kV interconnecting transmission line Tetovo - Prizren is also planed, through which an additional electricity interconnection with Kosovo would be established. The project further includes the establishment of a new 400/110 kV Tetovo Transformer Station, together with additional 400 kV transmission lines linking Tetovo with Ohrid and Skopje.

The plan for the investment package for the Southeast region is also significant. It includes a construction of a new 400/110 kV Transformer Station Miletkovo, a connection to a 400 kV transmission line Dubrovo - Thessaloniki, as well as the reconstruction of the 110 kV transmission line corridor between Transformer Station Valandovo, Transformer Station Strumica 2 and Transformer Station Strumica 1. In the same context, the construction of the new 400/110 kV power transformer in Transformer Station Dubrovo, with a power of 300 MVA, is also significant. In addition, an upgrade of the 400/110 kV Transformer Station Shtip with a second 400/110 kV power transformer is planned.

The significance of the above investments should be seen at two levels.

From the perspective of the distribution network, the modernization is aimed at the part of the system where new photovoltaic power plants and consumer-producers are mostly connected. It is at this level that the problems of increased decentralized production appear the most. Therefore, the transition to the 20 kV voltage level, the renovation of the medium-voltage and low-voltage network and investments in substations do not only represent technical modernization, but also a prerequisite for the network to be able to accept a larger number of producers without disrupting the quality and stability of the electricity supply.

From the perspective of the transmission network, the above-mentioned investments are aimed at enabling the system to absorb and transmit the electricity generated from renewable sources, the production of which does not always coincide with current local consumption.

When the production from photovoltaic plants is high, especially in periods of strong solar radiation and low consumption, a high transmission capacity is needed through which the excess electricity can be transmitted to other parts of the country or to neighboring power systems. Conversely, during periods of reduced production or increased consumption, strengthened interconnections and transformer stations allow for faster and more reliable import of electricity. Therefore, the projects concerning the transmission network are essential for controlling and managing of the fluctuations arising from renewable energy sources.

The increased interest in the construction of photovoltaic power plants cannot be considered separately from the capacity of the electricity grid. Although the natural conditions make North Macedonia suitable for development of solar energy, the success and sustainability of investments in this sector will largely depend on the implementation of the aforementioned projects aimed at strengthening the distribution and transmission electricity grid. Only through a timely increase in grid capacity, improving voltage conditions and creating stronger regional connectivity, the increased number of photovoltaic power plants in the country can be turned into a real advantage for the sale and trade of electricity.

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